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WEST OXFORDSHIRE DISTRICT COUNCIL

SALT CROSS GARDEN VILLAGE AAP

POLICY 2 – *NET ZERO CARBON DEVELOPMENT EVIDENCE BASE*

March 2025 I Rev K

Levitt Bernstein People.Design

Introba

Currie & Brown

Etude

Introduction

West Oxfordshire District Council (WODC) is in the process of preparing an Area Action Plan (AAP) to guide the future delivery of Salt Cross Garden Village – a planned new community near Eynsham.

Following examination hearings of the draft AAP in June/July 2021, the Inspector's final report concluded that the AAP is able to be adopted subject to a series of Main Modifications.

However, before the AAP could be adopted, a legal challenge was submitted by a third party organisation focused on the conclusions reached by the Inspector in relation to the soundness of AAP Policy 2 – Net Zero Carbon Development. The case was heard in the High Court in 2023 and the judgement confirmed that the Inspector's report and proposed Main Modifications are quashed insofar as they relate to Policy 2.

As a result, in April 2024, the examination was re-opened to consider the remitted part of the AAP. In her letter to WODC of 22 April 2024, the Inspector identified the need for evidence to address the criteria in the Government's Written Ministerial Statement (WMS) – 'Planning – Local Energy Efficiency Standards Update' published in December 2023.

This report has therefore been commissioned by West Oxfordshire District Council in response to the Inspector's request.

The report considers two different scenarios, the first being based on the use of energy-metrics and the second being based on Part L of the Building Regulations.

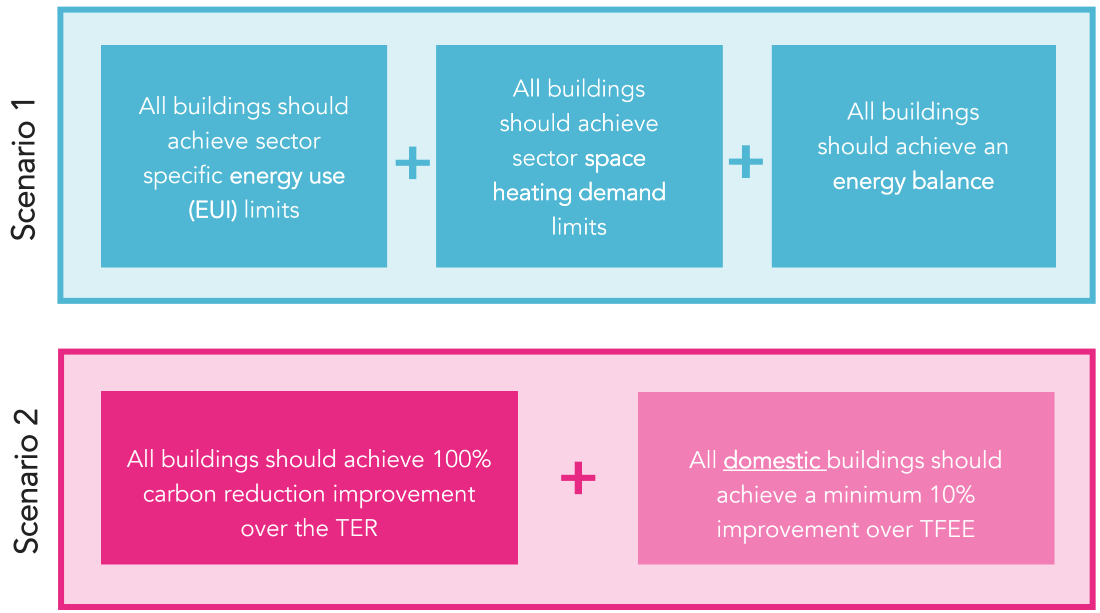
For each scenario, the report provides a technical and cost evidence base in order to demonstrate how technically feasible they are to deliver and the associated costs of each approach.

In terms of structure, Part 1 of the report provides a contextual overview with reference to relevant legislation, guidance and evidence of need.

Part 2 considers Scenario 1 – Net Zero Carbon Development based on the use of energy metrics including the technical and cost evidence base.

Part 3 considers Scenario 2 – Low Carbon Development based on the use of Part L of the Building Regulations including the technical and cost evidence base.

The appendix to the report provides information on the different energy efficiency assumptions used in both Scenarios 1 and 2. It also includes a series of relevant case studies outlining the approach which has been taken in a number of 'real world' schemes in other local authority areas.



Introduction

This evidence base has been prepared in 4 parts:

Part 1
Context

Part 2
Scenario 1: Net Zero Carbon Development

- Policy proposals
- Technical evidence base
- Cost assessment

Part 3
Scenario 2: Low Carbon Development

- Policy proposals
- Technical evidence base
- Cost assessment

Appendix

- Case studies
- Modelling Specifications
- Comparing Part L and predictive modelling

Thank you to the team at West Oxfordshire District Council who led this study:

WEST OXFORDSHIRE DISTRICT COUNCIL

Chirs Hargraves
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Hannah Kenyon

The consultant team includes architects, engineers, cost consultants and energy specialists from five different organisations, bringing together a diverse set of skills with a shared ethos of collaboration, practicality, and commitment to accelerate the reduction of carbon emissions from buildings.

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Contents

Part 1

Context and evidence of need

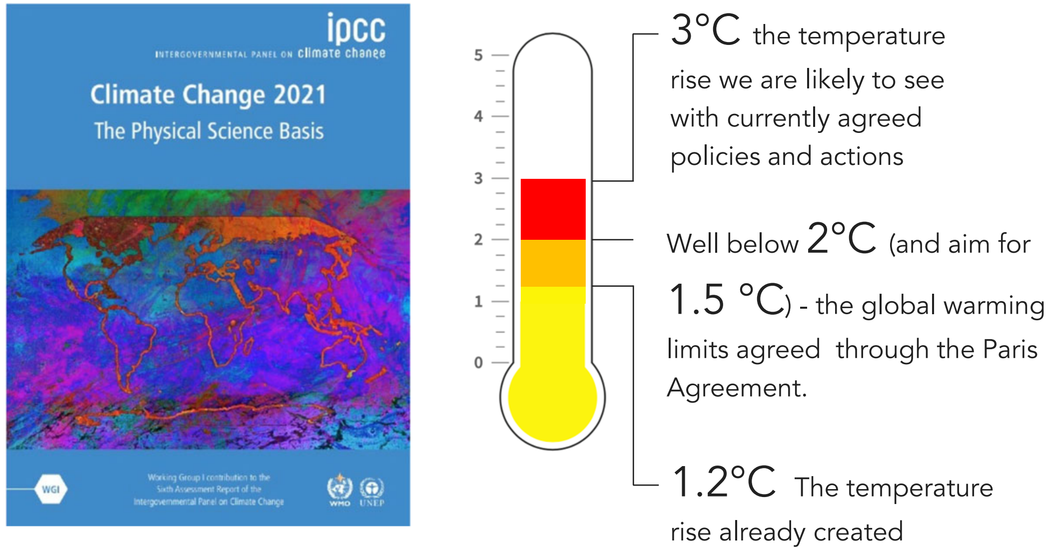
Global carbon reduction targets

There is a climate emergency

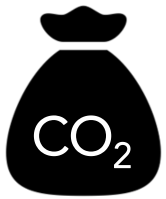
There is overwhelming scientific consensus that significant climate change is happening. This is evidenced in the latest assessment of the Intergovernmental Panel on Climate Change (IPCC AR6). The IPCC special report published in 2022 on the impacts of global warming of 1.5°C above pre-industrial levels highlights the urgency for action.

Implications for emission reductions

Scientists have proven that the temperature rise is not strongly dependent on when carbon emissions occur, only on their cumulative sum. This has led to the development of the concept of carbon budgets – that is the maximum amount of greenhouse gases that can be emitted in total before the threshold temperature is exceeded. The latest evidence on carbon budgets from Lamboll et al indicated a remaining global budget of 250 $GtCO_2$ at the start of 2023 for a 50% chance of limiting warming to 1.5˚C. If global emission rates continue at the present rate, the carbon budget will be consumed by the end of 2028. For the carbon budget to last until 2050, it is likely that emission reductions of at least 58% need to occur by 2030.



Latest IPCC report and the associated targeted limit on global warming: 1.5-2°C



250,000 $MtCO_2$

Remaining global carbon budget (from January 2023) for a 50% chance of limiting temperature rises to below 1.5°C (Lamboll et al, 2023). Includes updates to climate models and incorporation of new knowledge on contribution from non-CO_2 emissions.

<6 years

The number of years it would take to **consume our entire global carbon budget** at current global emissions rates for a 50% chance of limiting temperature rises to below 1.5°C

UK carbon budget

National commitment

The UK's national commitment is set through the Climate Change Act 2008, which was updated in 2019. It legislates that the UK must be net zero carbon by 2050 and sets a system of carbon budgets to ensure that the UK does not emit more than its allowance in the next 27 years. This legal requirement is underpinned by the Climate Change Committee's report 'Net Zero: The UK's Contribution to Stopping Global Warming'.

The carbon budget for the UK

The Climate Change Committee have produced a series of five year carbon budgets for the UK. While these are useful and have enabled the Committee to map out a 1.5˚C compliant policy pathway, the budgets are not directly comparable to the IPCC's carbon budgets due to variations in their scope over time.

Scaling the global carbon budget to the UK based on population indicates a remaining national carbon budget of 2,080 $MtCO_2$ as of the start of 2023.

Achieving Net Zero Carbon by 2050

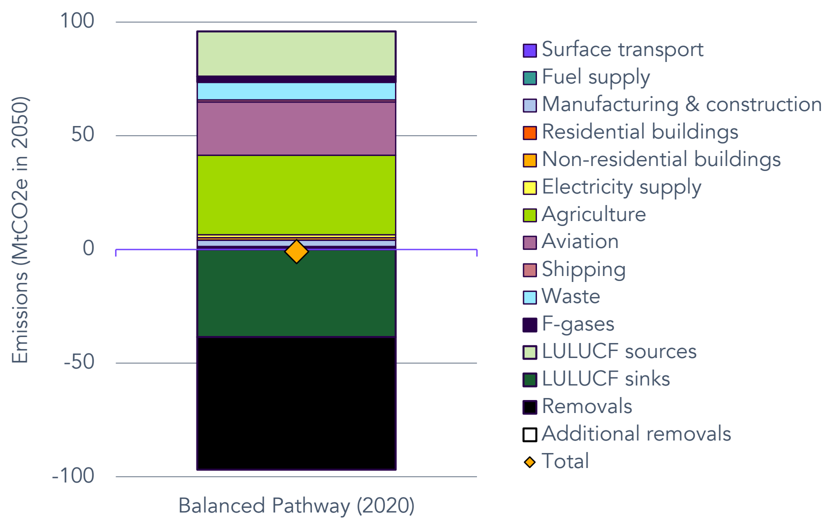
Key measures identified by the Climate Change Committee (CCC) include:

- 100% low carbon electricity by 2035.
- Ultra-efficient new homes and non-domestic buildings.
- Low carbon heat to all but the most difficult to treat buildings.
- Ambitious programme of retrofit of existing buildings.
- Complete electrification of small vehicles.
- Large reduction in waste sent to landfill or incinerators.
- Significant afforestation and restoration of land, including peatland.

250,000 $MtCO_2$ Global CO_2 budget

2,080 $MtCO_2$
UK budget (start of 2023)

The UK's remaining carbon budget for limiting warming to under 1.5°C was 2,080 Mt CO_2 at the start of 2023, based on scaling the remaining global carbon budget by population (note however if we were to account for the Equity Principle enshrined in the Paris Agreement the UK's carbon budget would be smaller. The UK also has a series of five year carbon budgets set by the CCC, however these are not directly comparable to the figure above as their scope has changed over time.



Residual emissions in the Sixth Carbon Budget "Balanced Pathway" scenario by sector. Emissions from buildings need to be almost eliminated. © Climate Change Committee

The national building regulations landscape

The current Building Regulations

The current section of the building regulations that governs energy and carbon emissions is Part L 2021. It came into force in June 2022 and is due to be replaced by the Future Homes Standard (residential) and the Future Buildings Standard (non-residential) in 2025.

Future Homes Standard (FHS)

The UK Government's proposed Future Homes Standard (FHS) aims to make all new homes 'zero carbon ready' by 2025 as an interim step towards net zero emissions by 2050. Key requirements cover:

- Energy efficiency (e.g. insulation, window performance and airtightness).
- Low-carbon heating systems in all new homes (no gas boilers).
- The potential requirement for PV systems.

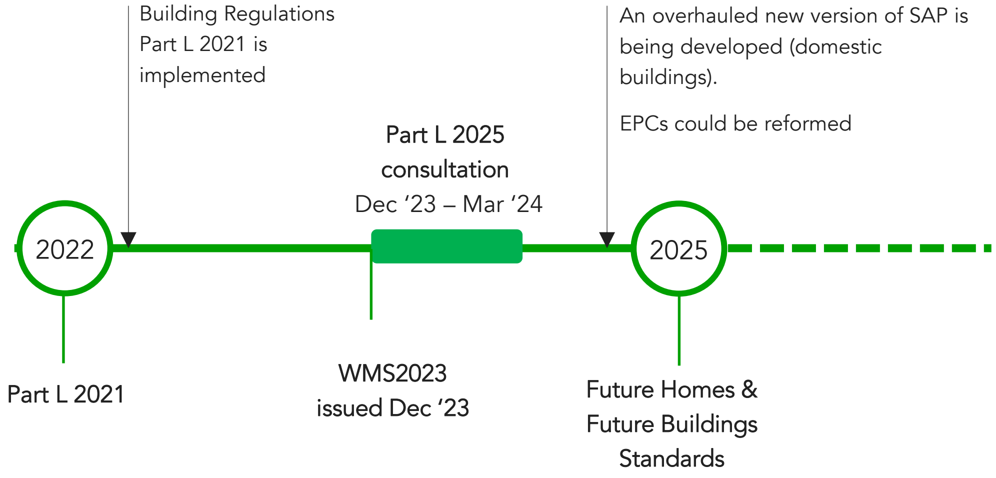
Future Buildings Standard (FBS)

The Future Buildings Standard (FBS) proposes changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new and existing non-domestic buildings.

The impact on Future Homes and Future Buildings Standards on this study

Although the Future Homes and Future Buildings Standards are welcome signs of the ambition to reduce carbon emissions from new buildings at Government level, there is not enough certainty on the proposed changes to influence this study significantly.

However, it is important to note that as policy scenario 2 is based on Part L 2021 it would need to be reviewed when Part L 2025 is introduced.



Policy changes are moving towards zero carbon, however there is much uncertainty surrounding the details.

Closed consultation

The Future Homes and Buildings Standards: 2023 consultation

Updated 4 March 2024

Applies to England

Contents

1. Scope of consultation
2. Acronyms
3. Introduction
4. Performance requirements for new buildings
5. Metrics
6. Updated guidance and minimum standards
7. Material Change of Use
8. Real-world performance of homes

The Future Homes and Buildings Standards: 2023 consultation on changes to Part 6, Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for dwellings and non-domestic buildings and seeking evidence on previous changes to Part O (overheating)

1. Scope of consultation

The Future Homes and Building Standards consultation ran between December 2023 and March 2024.

Current national building regulations

The Building Regulations set out the statutory standards developments are to meet.

Energy

These standards include Part L (2021), which came into force in June 2022 and sets the minimum energy performance that new buildings must achieve, including:

- The primary energy rate (kWh_{PE}/m^2).
- The carbon emission rate ($kgCO_2 /m^2$).
- For dwellings only, the fabric energy efficiency standard, FEES (kWh/m^2).

SAP 10.2 is the approved methodology to be used for Part L 2021 compliance modelling for dwellings and SBEM 6.1.e is the methodology for non-residential buildings.

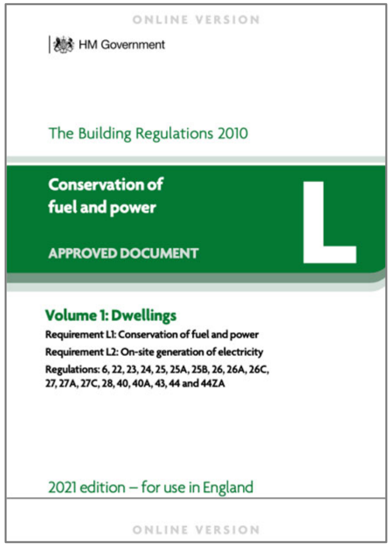
Part L 2021 calculations report the estimated carbon emissions of a building over the course of a typical year. However, these carbon emissions are calculated from regulated energy use only. This includes energy consumed for space heating, hot water, lighting, and pumps and fans, less any energy generated by renewable sources.

It is possible to calculate an estimated unregulated energy consumption through the Part L 2021 methodology, although this is not directly reported. Unregulated energy is consumed through electrical appliances and cooking.

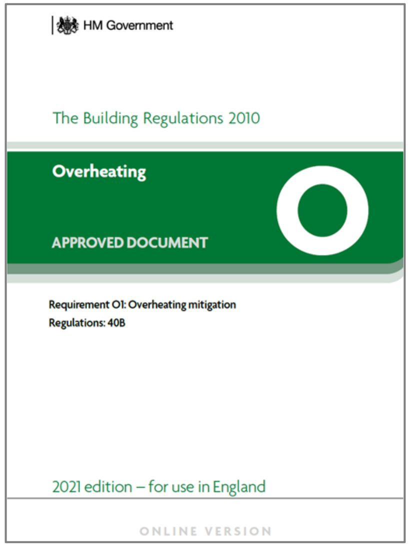
For SAP10.2 calculations, the calculations for unregulated energy use are heavily tied to the floor area of the dwelling. There is expected to be a change in the calculation under the Future Homes Standard which will come into effect in 2025.

Overheating (dwellings only)

Approved document O also came into force in June 2022. It sets a methodology and performance targets for the mitigation of overheating.


ONLINE VERSION
HM Government
The Building Regulations 2010
Conservation of fuel and power
L
APPROVED DOCUMENT
Volume 1: Dwellings
Requirement L1: Conservation of fuel and power
Requirement L2: On-site generation of electricity
Regulations: 6, 22, 23, 24, 25, 25A, 25B, 26, 26A, 26C, 27, 27A, 27C, 28, 40, 40A, 43, 44 and 44ZA
2021 edition – for use in England
ONLINE VERSION

Approved document L 2021 – Conservation of fuel and power


HM Government
The Building Regulations 2010
Overheating
O
APPROVED DOCUMENT
Requirement O1: Overheating mitigation
Regulations: 40B
2021 edition – for use in England
ONLINE VERSION

Approved document O 2021 – Mitigation of overheating in dwellings

Regional and local carbon reduction commitments

Oxfordshire's Strategic Vision

Oxfordshire's strategic vision for long-term sustainable growth sets out a number of principles and ambitions agreed by the six councils of Oxfordshire and key strategic partners. These include:

- (by 2050) to have energy efficient, well-designed homes.
- (by 2050) to have achieved carbon neutral status, and be accelerating towards a carbon negative future, removing more carbon than it emits each year.
- To be clean and green, placing the county at the leading edge of UK and global de-carbonisation efforts by maximising all opportunities to significantly reduce Oxfordshire's carbon footprint.
- Everything we build or design in Oxfordshire will be fit for purpose in the world of 2050.

"Our aim is to utilise the unique opportunities and assets in Oxfordshire to realise sustainable growth, and shape healthy, resilient communities in which it is possible for all residents to thrive and which can be an exemplar for the rest of the UK and other locations internationally."

Future Oxfordshire Partnership net zero route map and action plan

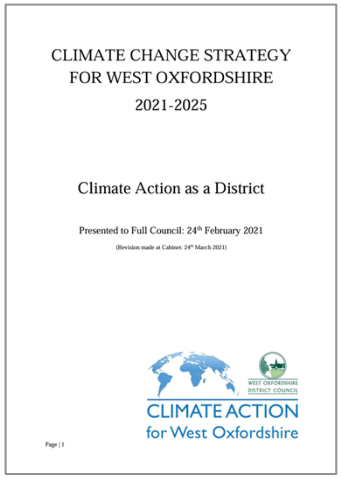
To support delivery of the strategic vision, the Future Oxfordshire Partnership commissioned a net zero action plan, which breaks down the ambitions by sector and sets specific objectives for each, including:

- From 2030 onwards, the target is for new builds to be built to Passivhaus Plus standards.
- To decarbonise industrial and commercial buildings.

"Building on existing work, such as Pathways to a Net Zero Carbon Oxfordshire (PaZCO) and the Zero Carbon Oxford Partnership (ZCOP), this study updates relevant evidence and sets out collaboratively developed actions, that are ambitious, locally owned and aligned to existing initiatives."

West Oxfordshire District Council Climate emergency

In June 2019, West Oxfordshire District Council passed a motion to declare a climate and ecological emergency and made a pledge to become a carbon neutral Council by 2030. The council's Climate Change Strategy was published in February 2021. It states that the council will implement climate policies.



"9.2 Strategic objectives 2021-2025

The Council will deliver its vision:

● taking action locally to accelerate the transition to net-zero carbon as a standard for all new development in West Oxfordshire, working with county and regional partners, landowners, developers and local residents.

● implementing climate policies, including targets for biodiversity net gain and net-zero-carbon development, at Salt Cross Garden Village as a requirement of the Area Action Plan (AAP)."

Industry definition of net zero buildings in operation

CCC guidance

In their UK housing: Fit for the future? Report the CCC provides clear guidance on what should be expected from new buildings from now on and in particular:

- an ultra-low level of energy use (i.e. 15-20 kWh/m^2.yr space heating)
- a low carbon heating system.

RIBA and LETI definitions

A significant amount of work has been undertaken and published by the Climate Change Committee (CCC), the Royal Institute of British Architects (RIBA), the Chartered Institute of Building Services (CIBSE), the UK Green Building Council (UKGBC), the Better Buildings Partnership (BBP), the Passivhaus Trust, the Good Homes Alliance (GHA) and the Low Energy Transformation Initiative (LETI).

The documents and guidance are consistent in their approach, and all have similar metrics that include:

- Energy Use Intensity (EUI) targets (kWh/m^2/yr)
- Embodied carbon targets kg CO_2/ m^2 either upfront embodied carbon (A1-A5) , lifecycle embodied carbon (A1-C4) or both.

Net Zero Carbon Buildings Standard

Various organisations including BBP, BRE, the Carbon Trust, CIBSE, IStructE, LETI, RIBA, RICS, and UKGBC have come together to develop a UK wide Net Zero Carbon Building Standard.

It provides a rule book to robustly prove that built assets are net zero carbon and in line with the UK's climate targets. It is be aligned with the UK's remaining carbon budget and Whole Life Carbon.

The pilot version was launched in September 2024, see www.nzcbuildings.co.uk

Industry publications on Net Zero

"New homes should deliver ultra-high levels of energy efficiency as soon as possible and by 2025 at the latest, consistent with a space heat demand of 15-20 kWh/m^2/yr. Designing in these features from the start is around one-fifth of the cost of retrofitting to the same quality and standard."

Extract from UK Housing: Fit for the Future? Committee on Climate Change, 2019.

Local Authorities have primary duties and powers to mitigate climate change

Primary duties to mitigate climate change

- The **Climate Change Act 2008** sets a clear direction for the UK. It obliges the government to set policy that will enable the UK to achieve Net Zero by 2050 at the latest and to meet its carbon budgets between now and 2050.
- The **National Planning Policy Framework 2024** recognises that the planning system should support the transition to net zero by 2050. Paragraph 162 requires that local plans should "take a proactive approach to mitigating and adapting to climate change".
- Section 19 of the **Planning and Compulsory Purchase Act 2004** requires that development plan documents must include policies designed to secure that development and use of land "contribute to mitigation of, and adaptation to, climate change".

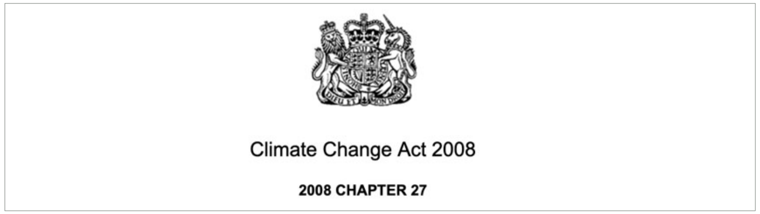
The CCC 2024 progress report: National policy is not enough

In its 2024 Progress Report to Parliament, the Climate Change Committee's assessment was that credible plans cover only a third of the emissions reductions required to achieve the 2030 target and only a quarter of those needed to meet the Sixth Carbon Budget. In particular, the CCC found that missing or incomplete policies included those on energy efficiency in buildings.

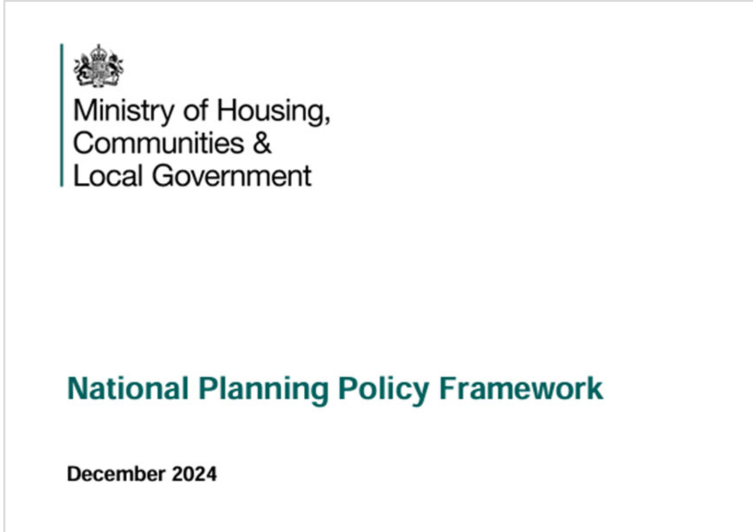
Primary powers to mitigate climate change

The **Planning and Energy Act 2008** empowers local plans to set "reasonable requirements" for new buildings to comply with "energy efficiency standards that exceed … building regulations" and "supply a proportion of their energy from nearby renewable or low carbon sources".

In their **response to the Future Homes Standard consultation** in 2021, the Government stated that "Local authorities have a unique combination of powers, assets, access to funding, local knowledge, relationships with key stakeholders and democratic accountability."

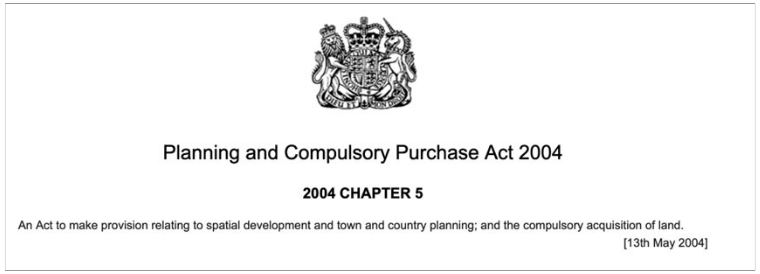

Climate Change Act 2008

2008 CHAPTER 27


Ministry of Housing, Communities & Local Government

National Planning Policy Framework

December 2024


Planning and Compulsory Purchase Act 2004

2004 CHAPTER 5

An Act to make provision relating to spatial development and town and country planning; and the compulsory acquisition of land.

[13th May 2004]


Planning and Energy Act 2008

Why a local policy is needed

Why existing national policies are not sufficient

Building regulations sets a minimum standard, not a level of performance consistent with WODC's ambitions for Salt Cross.

Building regulations are generally limited in ambition by what is possible in the least viable sites in England. WODC can determine the viability of setting better standards based on the local, not national, conditions.

Garden communities as exemplars of sustainable design.

When the UK Government launched the garden community initiative, it made clear the principles on which the villages should be based, including high quality homes designed to be 'future proofed', anticipating the needs and technologies for generations to come.

Garden communities are expected to embed the key qualities below.

a. Clear identity – a distinctive local identity as a new garden community, including at its heart an attractive and functioning centre and public realm.

b. Sustainable scale – built at a scale which supports the necessary infrastructure to allow the community to function self-sufficiently on a day-to-day basis, with the capacity for future growth to meet the evolving housing and economic needs of the local area.

c. Well-designed places – with vibrant mixed-use communities that support a range of local employment types and premises, retail opportunities, recreational and community facilities.

d. **Great homes – offer a wide range of high quality, distinctive homes.** This includes affordable housing and a mix of tenures for all stages of life.

e. Strong local vision and engagement – designed and executed with the engagement and involvement of the existing local community, and future residents and businesses. This should include consideration of how the natural and historic environment of the local area is reflected and respected.

f. Transport –integrated, forward looking and accessible transport options that support economic prosperity and wellbeing for residents. This should include promotion of public transport, walking, and cycling so that settlements are easy to navigate, and facilitate simple and sustainable access to jobs, education, and services.

g. Healthy places – designed to provide the choices and chances for all to live a healthy life, through taking a whole systems approach to key local health & wellbeing priorities and strategies.

h. Green space – generous, accessible, and good quality green and blue infrastructure that promotes health, wellbeing, and quality of life, and considers opportunities to deliver environmental gains such as biodiversity net gain and enhancements to natural capital.

i. Legacy and stewardship arrangements – should be in place for the care of community assets, infrastructure and public realm, for the benefit of the whole community.

j. **Future proofed – designed to be resilient places that allow for changing demographics, future growth, and the impacts of climate change** including flood risk and water availability, with durable landscape and building design planned for generations to come. This should include anticipation of the opportunities presented by technological change such as driverless cars and renewable energy measures.

Reducing energy costs for residents

A growing concern

Energy costs have always been a concern for those affected by fuel poverty and it is now a major issue for many UK residents.

The role of new buildings

There are three factors contributing to fuel poverty: energy prices (set by the market/energy suppliers), the household income and the dwelling's energy demand. The latter is the only criterion which can be positively influenced by the Local Plan and in particular by energy efficiency requirements for new buildings.

Electricity pricing is different to oil and gas

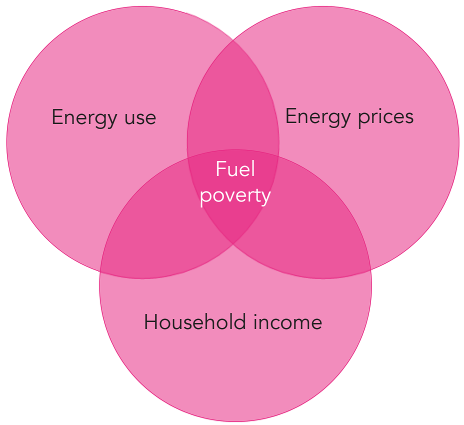
Although fossil fuel pricing can be volatile, prices paid by consumers for heating fuels usually vary over a period of weeks or months, as the wholesale prices of fuels change. Electricity prices by contrast can vary dramatically from one half hourly period to another as the UK's generation mix changes. During times of high wind or solar generation, prices often drop and can even become negative. Conversely, prices are usually higher when there is less wind and sun.

The two key benefits of energy efficiency

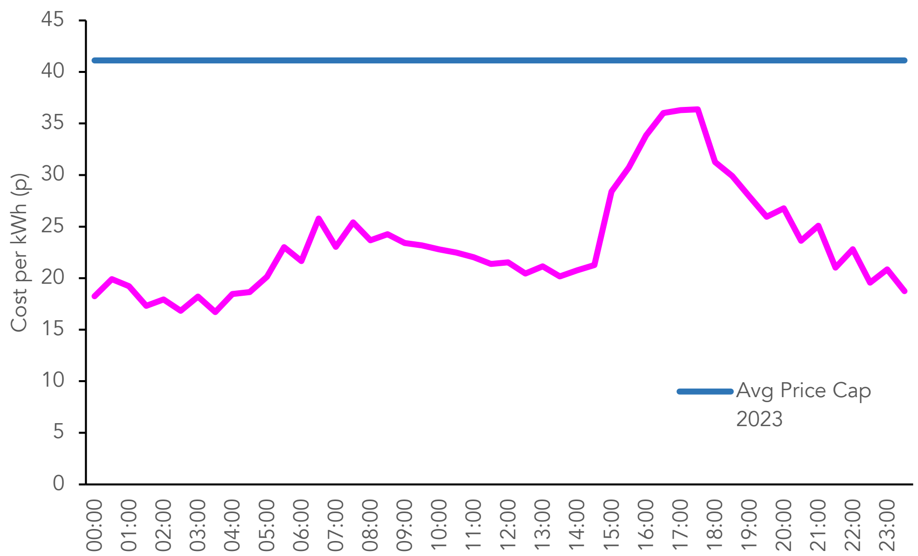
An energy efficient dwelling will help to reduce energy demand which in turn would reduce energy bills. It would also make the temperature more stable, enabling a 'smart' heating system to make the most of flexible dynamic electricity prices for homes paying by direct debit.

The positive role of renewable energy generation on bills

The proposed policy requires the incorporation of PV generation. This can and should benefit residents. A solar PV system can generate significant cost savings, including for residents using prepayment meters, when electricity is used by residents on-site, and some revenues through the export of electricity to the grid.



The dwelling's energy use is one of the three key factors contributing to fuel poverty. The proposed policy has a specific requirement for domestic buildings on energy efficiency.



Annual average half hourly prices for electricity from Octopus Energy's Agile tariff were significantly lower than the average price cap rate for standard fixed and variable tariffs in 2023. A similar pattern existed during 2018, 2019 and 2020 (ie years excluding the energy price crisis, which disrupted normal pricing).

Wider co-benefits of better insulated buildings

> "The right home environment protects and improves health and wellbeing. A warm, dry and secure home is associated with better health and prevents physical and mental ill health"
>
> Director of Public Health 2023 Annual Report

Lower carbon emissions are only one benefit of better insulated buildings

Better insulated buildings generally and housing specifically brings wider benefits to residents, communities and the region. Our homes are at the core of physical and mental wellbeing and should be places for people to thrive. Improving housing quality plays an important part in tackling health inequalities.

There are other co-benefits to policies promoting fossil fuel free, well insulated buildings:

Improving local air quality

Eliminating the burning of fossil fuels reduces air pollution locally as well as reducing carbon emissions to the atmosphere. Gas boilers produce carbon monoxide and nitrogen oxides.

Safety

There will be fewer accidents involving gas appliances and boilers.

Reducing costs to the NHS

Poor quality housing resulting in damp, mould, poor indoor air quality, excessive cold in winter, overheating in summer and other health impacts increases costs to the NHS. These effects especially impact the very young and very old.

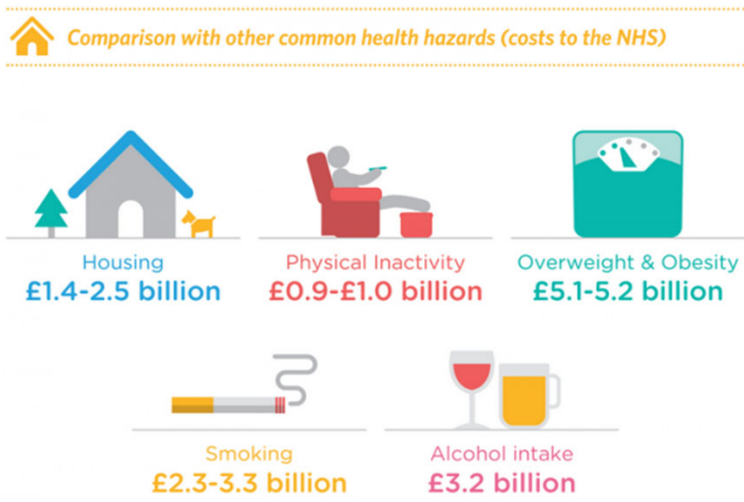
Skilled jobs in the local economy

Consistent policies of high-quality construction will support work for skilled installers, designers and maintenance operatives within the local area.

Combustion pollutants and their health effects

- Carbon monoxide (CO), a dangerous gas that when inhaled can interfere with the ability of blood to carry oxygen from the lungs to the rest of the body
- Nitrogen oxides (NOx), a respiratory irritant that causes airway inflammation, coughing, wheezing and increased asthma attacks
- Particulate matter (PM), a mixture of microscopic solids and liquids that affects multiple body systems and can increase the risk of premature death
- Air toxics, including as ammonia, formaldehyde, polycyclic aromatic hydrocarbons (PAHs) and volatile organific compounds (VOCs) that can cause cancer, birth defects and other serious health harms

Burning of fossil fuels including gas is a source of indoor and outdoor air pollutants. Source: American Lung Association



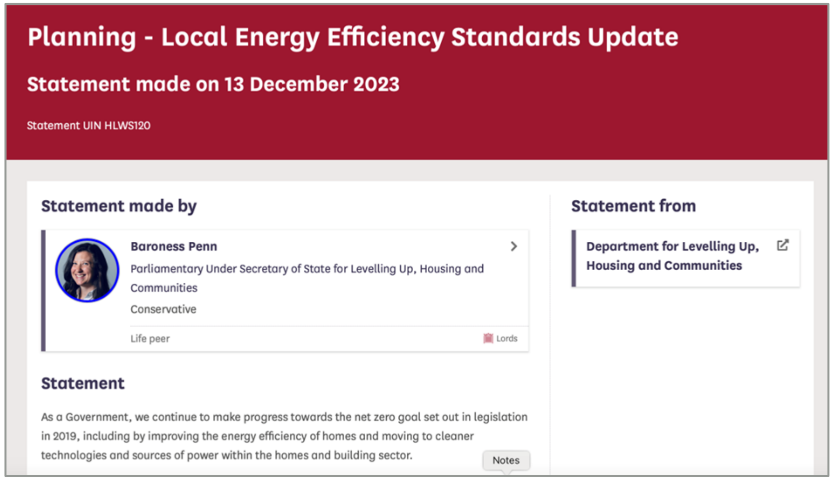
The Government predicts housing quality impacts will increase as the population ages. NHS costs source: BRE, (image source: gov.uk)

The 2023 WMS

The 2023 Written Ministerial Statement

A Written Ministerial Statement (WMS) was made on 13th December 2023 by the Parliamentary Under Secretary of State for Levelling Up, Housing and Communities. A key extract of the statement is:

> Any planning policies that propose local energy efficiency standards for buildings that go beyond current or planned buildings regulation should be rejected at examination if they do not have a well-reasoned and robustly costed rationale that ensures:
>
> - That development remains viable, and the impact on housing supply and affordability is considered in accordance with the National Planning Policy Framework.
> - The additional requirement is expressed as a percentage uplift of a dwelling's Target Emissions Rate (TER) calculated using a specified version of the Standard Assessment Procedure (SAP).



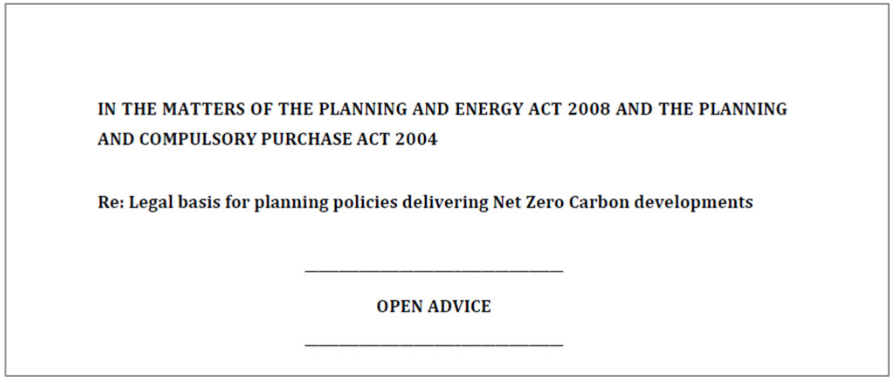
The 2023 Written Ministerial Statement on Planning – Local Energy Efficiency Standards Update can be found at https://questions-statements.parliament.uk/written-statements/detail/2023-12-13/hlws120

Reaction to the 2023 WMS

Open legal advice by Estelle Dehon KC concludes that the WMS should not prevent local authorities from exercising their statutory powers and duties.

It states: "So long as there is a robust evidence base – a reasoned and robustly costed rationale – it is open to examining inspectors, in the exercise of their planning judgment, to determine that policies based on [energy metrics] are consistent with national policy on climate change mitigation and the net zero obligation, and, to the extent that there would be deviation from the 2023 WMS, that can be justified on the evidence and does not prevent overall consistency of the proposed local plan with national policy (particularly as national policy can pull in different directions).

The low carbon scenario (2) is aligned to the stipulations of the WMS, although the net zero scenario (1) is also permissible.



IN THE MATTERS OF THE PLANNING AND ENERGY ACT 2008 AND THE PLANNING AND COMPULSORY PURCHASE ACT 2004

Re: Legal basis for planning policies delivering Net Zero Carbon developments

OPEN ADVICE

Open legal advice by Estelle Kehon KC

Part 2
Scenario 1: Net Zero Carbon Development

Technical and cost evidence base

2.1

Scenario 1: Net Zero Carbon Development – Policy Summary

Summary of Scenario 1: Net Zero Carbon Development

1 Energy efficient fabric and ventilation

Space heating demand (kWh/m$^2_{GIA}$/yr)

The building should achieve an ultra-low level of space heating demand, in line with the policy limit.

2 Low total energy use

Energy Use Intensity (EUI) (kWh/m$^2_{GIA}$/yr)

The predicted level of total energy use of the building (regulated and unregulated) should be less than the policy limit.

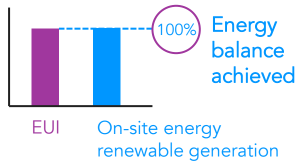
3 Fossil fuel free

Yes/ No

The building must not connect to the gas network or, more generally, use fossil fuels on-site. It must use a low carbon heating system (e.g. heat pump).

4 Zero operational carbon balance

kWh/m^{2}f$_p$ and % of total energy use



The building should seek to generate as much renewable energy as possible. Ideally there should be a balance between predicted annual energy use and annual renewable energy generation on the building. If this can't be achieved, then it must be achieved elsewhere on the site.

5 Measurement and verification

Post-occupancy energy monitoring should be carried out every year for the first five years of use of each building to understand the energy consumption of the development in-use. The results should be stored centrally and shared between developers, design teams and contractors on-site

6 Overheating

Overheating mitigation required

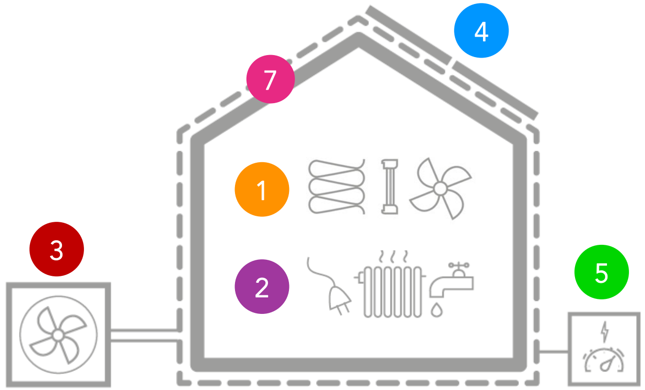
Residential buildings to comply with Part O of the Building Regulations. Non residential buildings require compliance with CIBSE TM52.

7 Embodied carbon

Upfront carbon limit (kgCO_2e/m$^2_{GIA}$)

Development proposals will need to demonstrate attempts to reduce embodied carbon to meet the UK Net Zero carbon building standard upfront carbon limits.

Building typologies	Space heating demand (kWh/m$^2_{GIA}$/yr)	Energy Use Intensity (EUI) (kWh/m$^2_{GIA}$/yr)
Detached homes	20	35
Semi-detached, terraced homes and flats	15	35
Office	15	70
School	15	65
Science and tech	15	Refer to Appendix C
Retail	15	Refer to Appendix C



Predictive energy modelling should be used to demonstrate compliance, not Part L modelling

Part L modelling

SAP (domestic) and the National Calculation Methodology (NCM) (non domestic) are the calculation methodologies used to demonstrate compliance with Part L of the Building Regulations.

- SAP (Standard Assessment Procedure) is used through the associated SAP software
- the NCM and (National Calculation Methodology) through SBEM and Dynamic Simulation Modelling (DSM) tools.

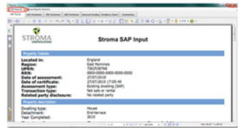
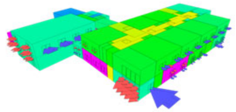
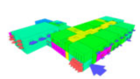
Current policy relies on these tools.

However, until now, these Part L energy assessment methodologies were developed only to check compliance with Building Regulations. They were never meant to perform key functions that are required to deliver Net Zero carbon buildings, and most importantly they were not meant to predict future energy use accurately. This is a widely accepted fact in the industry. This is why the use of predictive energy modelling is required to demonstrate compliance with Net Zero requirements.

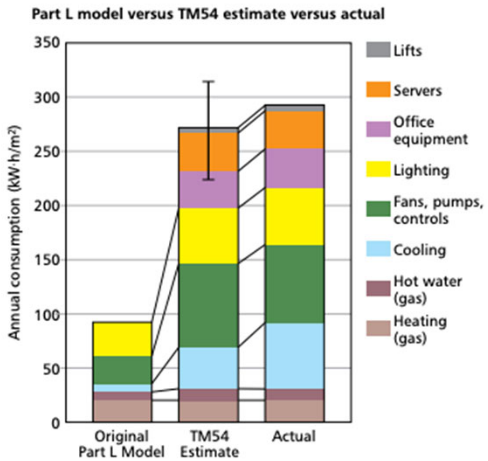
The need to use predictive energy modelling

The accuracy of energy modelling is important to ensure it provides a reasonable indication of buildings' future energy use. While behaviour of the users may vary once a building is occupied, predictive energy modelling can be used to reliably estimate energy use and to drive suitable design and construction decisions.

- For domestic buildings, the PHPP methodology and excel based tool have been shown to predict energy use much more accurately than the current version of SAP.
- For non domestic buildings, predictive energy modelling using the methodology set out in CIBSE Technical Memorandum 54 (TM54) allows estimation of the operational energy for all end uses of a building. IESVE, TAS and PHPP are three energy modelling packages that can be used to carry out TM54 assessments.

	Part L modelling	Predicted energy use modelling
Domestic	 SAP (Part L1A)	 PHPP
Non-domestic	 NCM (Part L2A)	  PHPP or DSM (TM54)

There is a significant difference between Part L modelling currently used to demonstrate compliance with planning policy and predictive energy use modelling which must be used to demonstrate compliance with the proposed policies.



In the UK, energy models are used at the design stage to compare design options and to check compliance with Building Regulations. These energy models are not intended as predictions of energy use, but are sometimes mistakenly used as such.

In some other countries, total energy use at the design stage is estimated through voluntary standards. For example, the Australian NABERS (a building rating system) encourages the estimation of energy use at the design stage and provides guidance for designers/modellers.

Extracts of CIBSE Technical Memorandum 54 (TM54): Evaluating operational energy performance of buildings at the design stage

Space heating demand and Energy Use Intensity

Space Heating Demand (SHD)

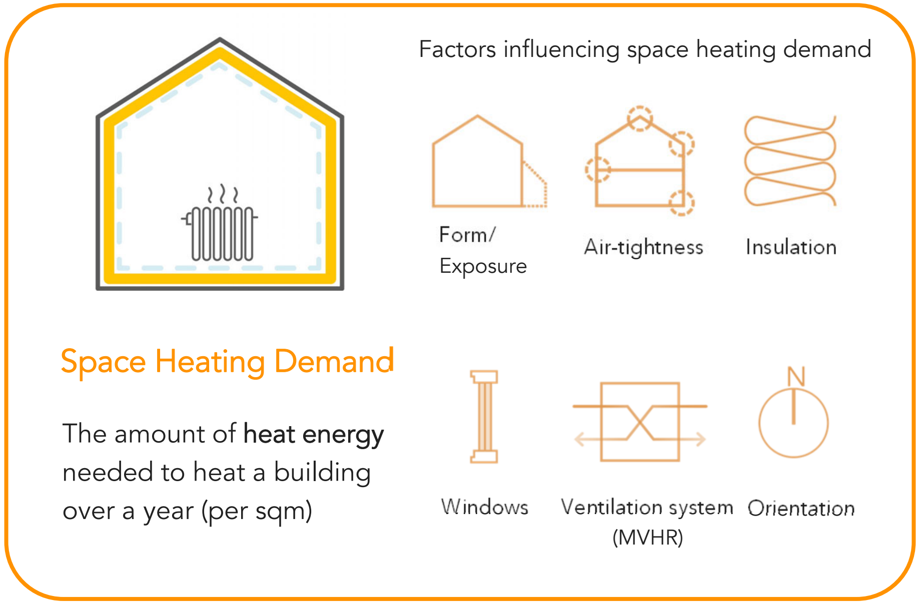
Various design and specification decisions affect space heating demand including building form and orientation, insulation, air-tightness, windows and doors and the type of ventilation system. The Climate Change Committee recommends a space heating demand of less than 15-20 kWh/m^2/yr for new homes, therefore the policy requirement on space heating demand could be that all buildings should achieve a space heating demand of less than 15-20 kWh/m$^2_{GIA}$/yr.

Energy Use Intensity (EUI)

For new buildings to be compliant with West Oxfordshire district councils climate change targets, they need to use a total amount of energy which is small enough so that it can be generated entirely, on an annual basis, with renewable energy and low carbon resources. The EUI metric is also very beneficial as it can be measured post-construction, therefore helping to reduce the performance gap which is such a significant issue in the construction industry.

Depending on the typology recommended Energy Use Intensity (EUI) of no more than a maximum limit is provided. (e.g. 35 kWh/m$^2_{GIA}$/yr for domestic).

Implementation: To ensure best practice - require predictive energy modelling (e.g. using PHPP or CIBSE TM54 or equivalent) with the intention to meet the space heating demand and energy use intensity limit. Modelling should be carried out: as part of the detailed planning submission, be reconfirmed pre-commencement, validated pre-occupation and monitored post-completion.



The space heating demand metric

Energy Use Intensity (EUI): a simple, measurable metric

What is the EUI?

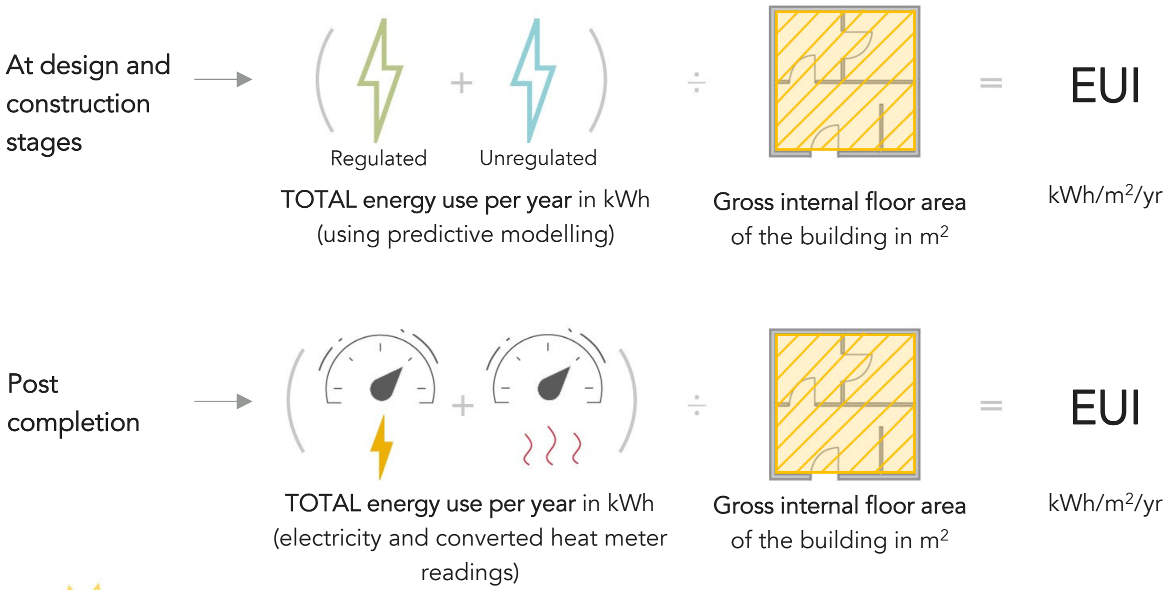
The Energy Use Intensity (EUI) represents the total amount of energy used by a building divided by its floor area (GIA). This includes any spaces within the thermal line of the building, such as: living and dining, bedrooms and communal/circulation spaces. It is reported in kWh/m^2.year. It is based on delivered energy and does not need to be converted in primary energy using any factors.

The EUI is a good indicator of the energy efficiency of a home/building and can be calculated or checked at both design stage and post completion. For homes/buildings heated by an individual heating system, it is will be very easy to check for the occupant/resident as it will be the annual 'energy at the meter' divided by the floor area.

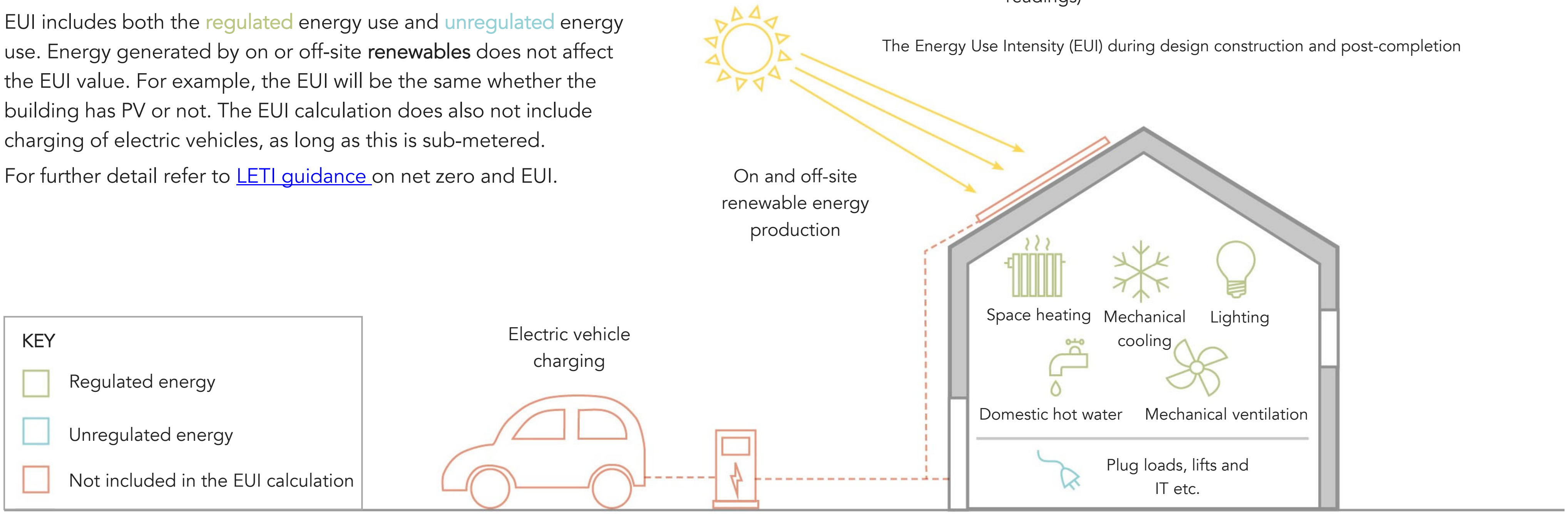
What is included in the EUI?

EUI includes both the regulated energy use and unregulated energy use. Energy generated by on or off-site **renewables** does not affect the EUI value. For example, the EUI will be the same whether the building has PV or not. The EUI calculation does also not include charging of electric vehicles, as long as this is sub-metered.

For further detail refer to LETI guidance on net zero and EUI.



The Energy Use Intensity (EUI) during design construction and post-completion



What is included in the EUI?

Note: EUI should not be confused with Primary Energy which rely on the multiplication of energy use by primary energy factors specific to each fuel (similarly to carbon emissions which rely on the multiplication of energy use by carbon factors.

On-site renewable energy generation and energy balance

Onsite renewables are a key component of net zero

In order for a building to be net zero, renewable energy must be generated to balance the annual energy use of the building. This balance should ideally happen within the site boundary. This typically means installing solar PVs on the roof of the development.

The amount of energy that can be generated depends on the energy intensity of the building (residential homes use less energy per floor area than offices or hotels), and the number of storeys of the building. For taller buildings there is less roof area available per GIA compared to smaller buildings.

Installing PVs on the building reduces the energy bill of residents

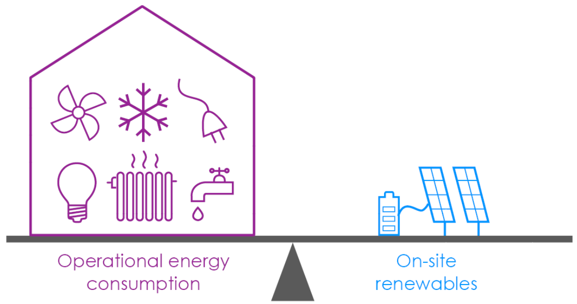
Although the carbon reductions remain the same if the Solar PV is installed on the building or on the plot, the cost benefits to the residents only apply to the Solar PV that is installed on the building.

The benefits of self consumption

The cost effectiveness of Solar PV changes depending on how much of the energy that is being generated is being used by the building at the time that it is generated, and how much is sold back to the grid.

It is much more cost effective to use the electricity than to sell it to the grid, as the price that householders can sell the electricity for is less than the price that they purchase electricity.

Solar PV systems installed on single family homes are a very effective way of reducing energy bill of the residents. On blocks of flats the electricity is unfortunately often only used for landlord energy consumption due to technical challenges (e.g. wiring, metering). There are however technologies available, such as SolShare, which takes the electricity generated by a a single PV array on a block of flats and distributes it equally between the flats. This enables the occupants to use this free electricity.



Energy balance

The amount of renewable energy generated in a year matches should match or exceed the EUI

A key component of a net zero carbon building is achieving an energy balance – the amount of renewable energy generated in a year should match the energy used by the building in a year.

Overheating, energy measurement, embodied carbon

Overheating

Modelling shall be undertaken to show compliance with Part O for residential and TM 52 for non-residential.

Where the energy efficiency of a building is improved and as the climate changes there is a greater risk of overheating in buildings. Overheating should be avoided though good design and mechanical cooling should only be included as a last resort.

At outline planning stage overheating should be mitigated through appropriate orientation and massing. A statement on the likely strategies that could be implemented at detailed planning stage should be covered.

At detailed planning stage the applicant should submit overheating calculations in line with the latest Part O or TM52 guidance, demonstrating that the homes are not expected to overheat.

Mitigation measures should be included where possible to prevent overheating in future climate scenarios. This may include the flexibility of designs to have future measures installed at a later date.

Design for the mitigation of overheating should be demonstrated as part of the outline planning submission. Overheating calculations should be carried out as part of the detailed planning submission and reconfirmed pre-commencement.

Embodied carbon

Development proposals will need to demonstrate attempts to reduce embodied carbon, to meet the upfront carbon limits the UK Net Zero Carbon Buildings Standard. (Building Life Cycle Stages A1-A5). Includes Substructure, Superstructure, MEP, Facade & Internal Finishes, excludes on site renewables.

As part of the submission of any planning application, a report should be prepared which demonstrates the calculation of the expected upfront embodied carbon of buildings. Full lifecycle modelling is encouraged.

Embodied carbon calculations should be carried out as part of the outline and detailed planning submission, be reconfirmed pre-commencement, and validated pre-occupation.

Measurement and verification

Meter, monitor and report on energy consumption and renewable energy generation post-completion for the first 5 years.

It is important that where buildings are designed to be net zero operational carbon that they also perform to this standard when complete.

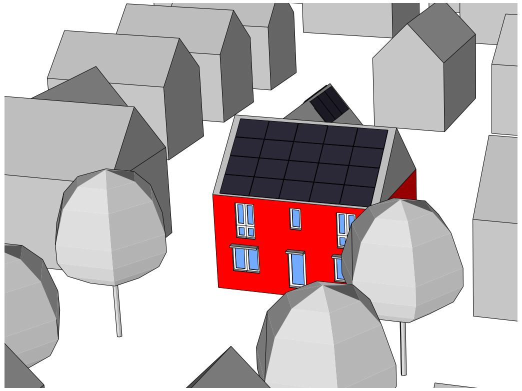
Applicants should confirm the metering, monitoring and reporting strategy as part of the detailed planning application. There should be a commitment to monitor consumption and report on it.

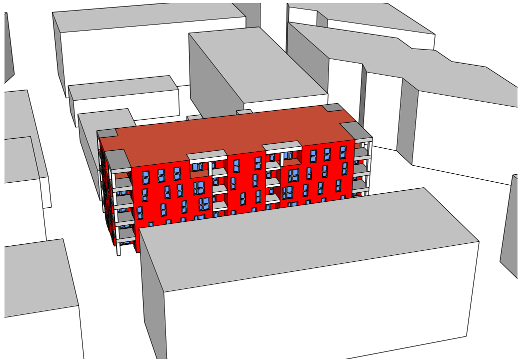
2.2

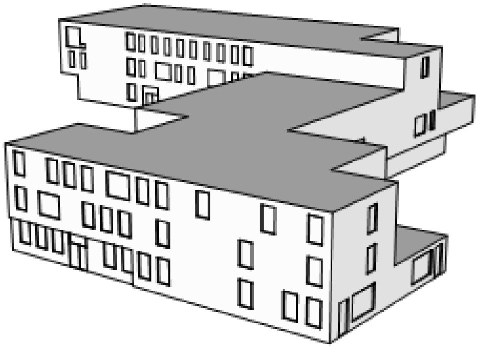
Technical evidence base

Summary of the modelling methodology and results

The purpose of the energy and cost modelling







Purpose of energy and cost modelling

The purpose of this modelling is to determine that Scenario 1 is:

a) Feasible from a technical perspective and to support the determination that they are also:

b) Has a cost uplift associated with it that feeds into the viability assessment.

Energy modelling

The energy modelling purpose is to investigate how different building archetypes perform under scenario 1 Net Zero Carbon, against the specification Part L 2021. These results constitute the evidence that the considered policies are technically achievable and are also used to inform the cost models and viability testing.

The residential predictive energy modelling uses the climate file GB0027a-Northolt, closest to Oxfordshire. The non-residential modelling uses CIBSE Swindon weatherfile. The solar radiation calculations for PV systems assume conditions in Oxford for accuracy. This modelling reflects current weather. There are future weather files available which anticipate the warming expected in the medium term. These can be used to understand how the overheating risk may increase but are not used in predictive energy modelling carried out in this study.

Cost modelling

The cost modelling estimates the additional cost of meeting Scenario 1 net zero carbon over a baseline of building regulations compliance (Part L 2021). These results then will be used to inform policy viability assessments.

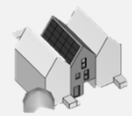
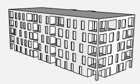
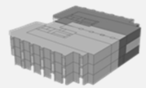
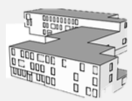
The cost modelling uses local cost indices.

Technical feasibility | Summary of findings

Energy modelling using PHPP or CIBSE TM54 was undertaken to estimate space heating demand and the total energy use (EUI) for each scenarios for the different domestic typologies.

In summary:

- **A space heating demand of 20 kWh/m^2.yr can technically be achieved by the Detached house 15 kWh/m^2.yr by all other domestic and non-domestic typologies.** It relies on the net zero level of fabric and ventilation specifications.
- **An Energy Use Intensity (EUI) of less than 35 kWh/m^2.yr can technically be achieved by all domestic typologies and less than 70 kWh/m^2.yr for office and less than 65 kWh/m^2.yr for a school.** Different heating and hot water systems can be applied. For the terrace house, low-rise apartment building and mid-rise apartment building typologies, a heat pump is required to meet the EUI target. For the high-rise apartment building typology direct electric is also an option.
- All typologies use a low carbon heating system (e.g. heat pump) and are fossil-fuel free.
- The scenarios highlighted above are all compliant with Part L 2021

Building typologies	Building regulations Part L 2021	Space heating demand (kWh/m^2·yr)			Energy use intensity (EUI) (kWh/m^2.yr)			Fossil fuel free
		Target	Result	Met	Target	Result	Met	
 Detached house	✓	≤20	20	✓	≤35	28	✓	✓
 Terraced house	✓	≤15	13	✓	≤35	29	✓	✓
 Mid-rise apartment building	✓	≤15	13	✓	≤35	31	✓	✓
 Office	✓	≤15	15	✓	≤70	69	✓	✓
 School	✓	≤15	10	✓	≤65	57	✓	✓

Summary of space heating demand, energy use intensity and Part L compliance results

2.2.1

Technical evidence base- Residential

Summary of the modelling methodology and results

Residential typologies

To conduct the energy and cost modelling for this technical evidence base, a selection of domestic typologies was identified and assessed.

We have focused on three prominent types for residential houses: detached, terraced town house and mid-rise block of flats. These types were determined through discussions with the Council and analysis the Grosvenor planning application. Specifications for each typology have been outlined (see adjacent images).

Predictive energy modelling outputs

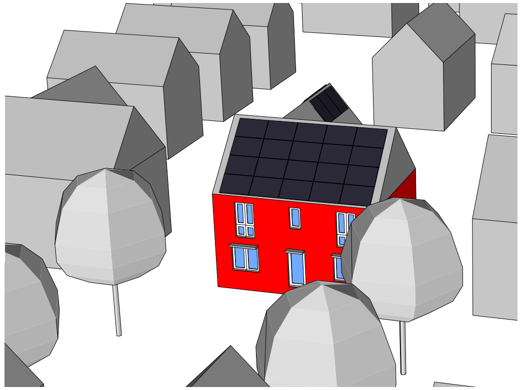
The buildings were modelled using a predictive operational energy modelling tool PHPP Version 10.4 for domestic buildings. The tool was used to calculate the space heating demand (SHD) and Energy Use Intensity (EUI) for each scenario and each building.

See the appendix for assumptions related to fabric and systems.

Detached House

A 4-bed detached house has been selected for modelling.

GIA: 141 m^2



Terraced Town House

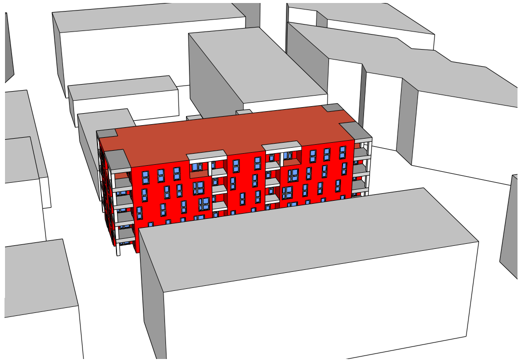
A 3-bed terraced town house has been proposed as a representative example and will be modelled with an additional unheated parking area below.

GIA: 101.5 m^2

Mid-rise block of flats

A 5-storeys block of flats has been selected for modelling.

GIA: 3,140 m^2 (whole building)



Residential typologies I Predictive modelling - summary of results

The results of the performance modelling analysis for the three residential typologies are presented here.

The analysis shows that the space heating demand and Energy use intensity limit are technically feasible. The Net Zero Carbon scenario meets the limit outlined in the policy.

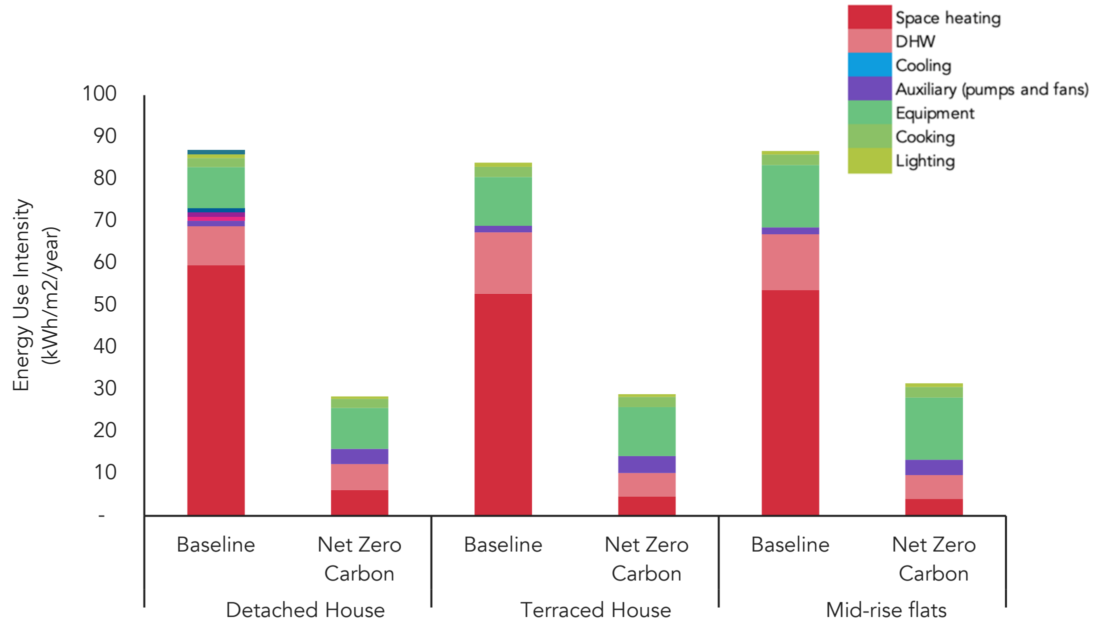
Total energy use

The significant reduction in total energy use between the baseline and the Net Zero Carbon scenario is due to the increased fabric and the use of an Air Source Heat Pump to provide space heating and hot water for the Net Zero Carbon scenarios as opposed to a gas boiler in the baseline scenarios.

For **Space Heating Demand,** Net Zero carbon scenario cut demand drastically: detached houses drop from 58 to 20 kWh/m²/yr, terraced houses from 50 to 13 kWh/m² /yr, and mid-rise flats from 55 to 13 kWh/m² /yr. This shows the effectiveness of improving the building fabric and heating systems beyond Part L of the building regulations.

The **Energy Use Intensity** of the net zero scenario improves significantly, with detached houses reducing from 83 to 28 kWh/m^{2GIA}, terraced houses from 84 to 29 kWh/m^{2GIA} /yr and mid-rise flats from 87 to 31 kWh/m^{2GIA} /yr.

	Detached House		Terrace House		Mid-rise block of flats	
	Baseline	Specs modelled	Baseline	Specs modelled	Baseline	Specs modelled
Space Heating Demand (kWh/m^{2GIA}/yr)	58	20	50	13	55	13
Energy Use Intensity (kWh/m^{2GIA}/yr)	83	28	84	29	87	31



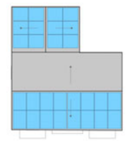
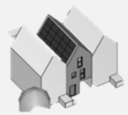
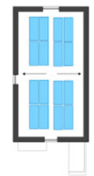
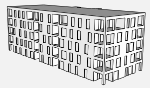
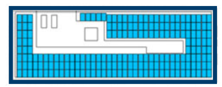
Residential typologies I PV Analysis

The policy requires an energy balance, this means that the total renewable energy must meet or exceed the predicted energy consumption of the buildings. Analysis was carried out to understand the maximum amount of Solar PV that fits on the roof of the developments, and if this meets the predicted energy used by the development.

An energy balance can be met for the detached house, if it faces North /South or East/West.

An energy balance can be met for the terraced house if the roof faces East/West. The saw tooth roof of the terraced house is not optimised for solar PV generation, as the pitches of the roofs self-shade. This means that the area of the roof that is suitable for Solar PV is reduced. Solar PV panels can only be placed close to the ridge of the roof.

An energy balance can't be met for the mid-rise apartment by solar panels on the roof alone, due to the number of storeys of the development. Due to it being a flat roof, it can benefit from East-west orientation of the panels despite the building orientation. 88% of the energy balance can be met on the roof, to balance the remaining energy consumption 138m² of panels would need to be provided elsewhere in the development.

Building typologies	PV energy generation (Proportion of energy balance)				
	Target	East-West orientation		North-south orientation	Can it be met on the building?
 Detached house	Energy Balance	N 	202%	151%	✓
 Terraced house	Energy Balance	N 	138%	71%	✓
 Mid-rise apartment building	Energy Balance	N 	88%	n/a	✕

Summary of PV energy generation for each domestic typology

2.2.2

Technical evidence base- Non residential

Summary of the modelling methodology and results

Non-residential typologies

Selection of the typologies for modelling

To conduct the energy and cost modelling for this technical evidence base, a selection of non-domestic typologies was identified and assessed.

We have focused on two types for non-residential buildings: Schools and office. These types were determined through discussions with the Council. Specifications for each typology have been outlined (see adjacent images).

Predictive energy modelling outputs

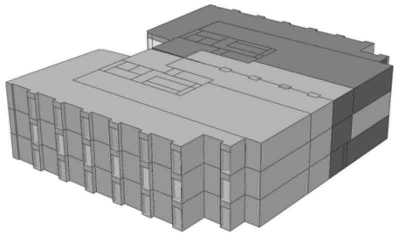
The buildings were modelled using a predictive operational energy modelling tools. The office was modelled in IESVE and the School was modelled in TAS. The tools were used to calculate the space heating demand (SHD) and Energy Use Intensity (EUI) for each scenario and each building.

See the appendix for assumptions related to fabric and systems.

Office

The images here represent the 3-storey office block that has been selected for modelling.

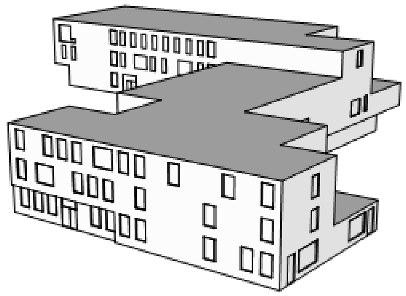
GIA: 4000 m^2



School

A representative secondary school with 3-4 stories, additional changing and IT space

GIA: 6000 m^2



Office and Primary School I Predictive modelling

The results of the predictive modelling analysis for the primary school and office are presented here.

The analysis shows that the space heating demand and Energy use intensity limit are technically feasible. The Net Zero Carbon scenario meets the limits outlined in the policy.

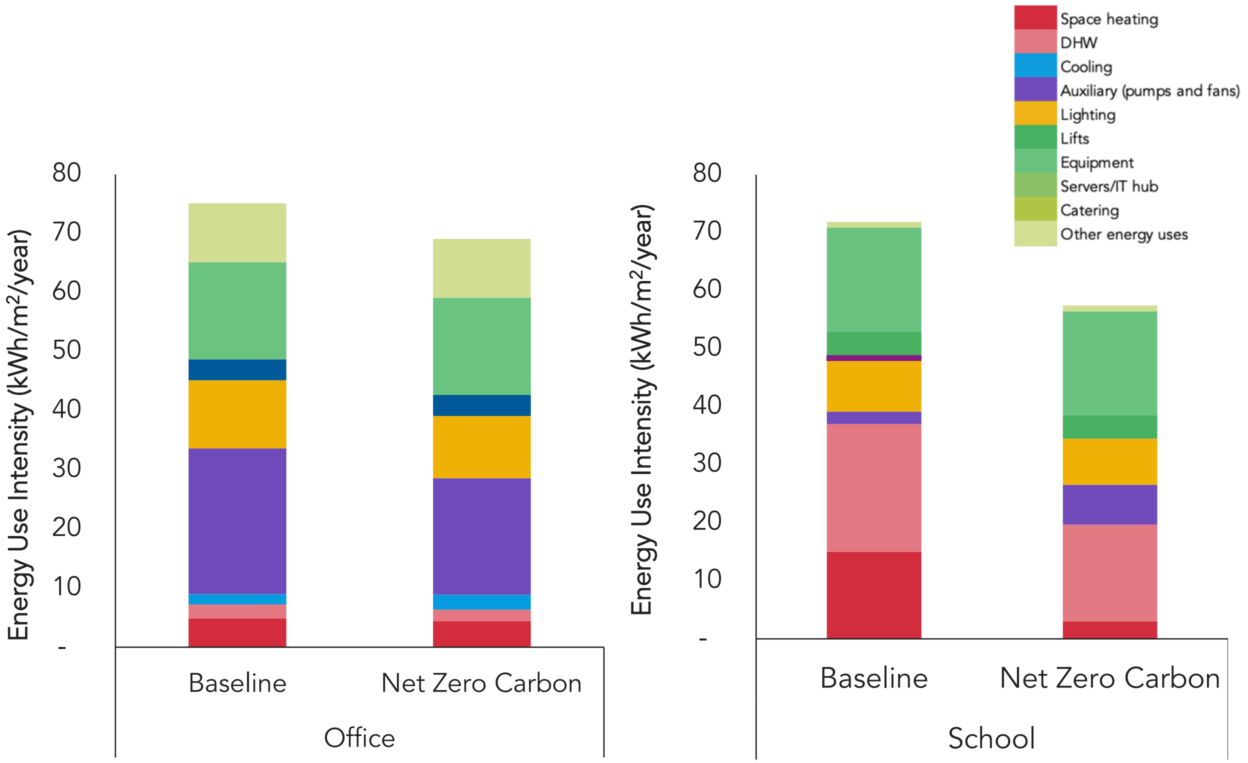
Total energy use

The reduction in total energy use between the baseline and the Net Zero Carbon scenario is due to the increased fabric performance. Air Source Heat Pumps are used in both the baseline and Net Zero Carbon scenarios to provide space heating and hot water.

For **Space Heating Demand**, Net Zero carbon scenarios cut demand significantly (10% and 85%).

The **Energy Use Intensity** of the net zero scenario improves with the office reducing from 75 to 69 kWh/m²ᴳᴵᴬ/yr, and the school from 70 to 57 kWh/m²ᴳᴵᴬ/yr. For both typologies, the energy performance is dominated by uses other than space heating, so the fabric performance, whilst significant, does not radically change the overall total energy consumption.

	Office		School	
	Baseline	Specs modelled	Baseline	Specs modelled
Space Heating Demand ($kWh/m^{2GIA}/yr$)	17	15	37	10
Energy Use Intensity ($kWh/m^{2GIA}/yr$)	75	69	70	57



Non-residential typologies I PV Analysis

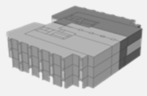
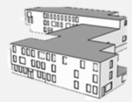
A summary of the results of modelling to assess how much could be accommodated for the non-residential buildings are shown in the table to the right. Neither typology is able to meet the policy with only roof mounted PV, thus further Solar PV will need to be provided on-site.

Overshading

Overshading from trees or nearby buildings can significantly reduce the viable space for PV. The modelling assumes no significant shading for these buildings, as they are expected to be as tall or taller than the surrounding properties.

Competing requirements for roofs

For non-residential buildings, there are often competing uses for flat roofs which reduce the space available. Fire breaks, vents to fire stairs, air source heat pumps and associated plant and access for cleaning have all been considered in the modelled results, which show that not all are able to achieve a 100% energy balance with roof mounted PV. Other policy led requirements which could impact this further include amenity spaces and green roofs to meet biodiversity net gain targets.

Without competing roof requirements					
Building typologies		PV energy generation (kWh/m²building footprint)			
	Building area footprint (m²)	Target to Achieve Energy Balance	Max PV Available on Roof	Additional PV required to meet Energy Balance	Can it be met on the building?
 Office	1164	Energy Balance	59%	416 m²	✗
 School	1408	Energy Balance	78%	182 m²	✗

Summary of PV energy generation for each non-domestic typology, modelled results in blue, additional provision shown in grey.

2.3

Cost evidence base

Summary of the modelling methodology and results

Cost analysis summary

The cost analysis was carried out to inform the viability assessment that will be carried out.

A summary of the cost analysis is shown to the right.

The capital cost uplift to policy scenario 1 is 1.7%-6.8% higher than the baseline.

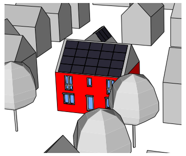
There is always a running cost reduction with scenario 1. For retail and science buildings this over 100% of the baseline running cost because the buildings are a net exporter of electricity.

As always with costs, it is important to understand how these assessments were undertaken as well as their limitations. In particular, the costs models are based on the buildings modelled. Although the trends and scale are expected to be similar for other buildings within the same archetype, variations are possible. This is particularly the case for housing where different developer sizes, specifications and delivery models will influence costs.

	Capital Costs	Running Costs
Detached House	+5.6%	-9%
Terrace House	+6.8%	-15%
Mid-rise Flats	+5.4%	-39%
School	5.3%	-85%
Office	+2.7%	-67%
Retail	+6.6%	-110%
Science & Tech	+1.7%	-133%

Summary of uplift in total capital costs and percentage reduction of running and maintenance costs compared to baseline for 25 years

Detached house | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+5.6%

The adjacent table provides a summary of the specifications which were compared:

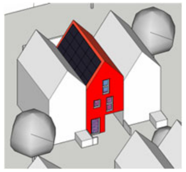
- The **baseline** scenario represents a home build in accordance with the Part L2021 notional building specification. This is based on a cost range in the top quartile of BCIS rates for houses for the period 2020-2024 and for includes a cost uplift of £48/m² over the base cost to allow for works to achieve Part L 2021 (enhanced roof insulation, windows and PV).
- **The additional construction cost of scenario 1 is estimated to be 5.6%.** Scenario 1 incorporates a higher standard of fabric energy efficiency, a more efficient MVHR system and the switch to a heat pump. The size of the solar PV array to meet the energy balance is slightly smaller than the requirements of the baseline, so this represents a cost saving.
- The 25 year running and maintenance cost of policy scenario 1 are 8.5% lower than the baseline.

	Baseline	Scenario 1- Net Zero
Fabric & ventilation	Part L 2021	Space heating demand limit
Heating	Gas boiler and waste-water heat recovery	Heat pump
Renewable energy on building	Part L baseline	To meet energy balance
	4.8 kWp	4.0 kWp

	Baseline	Scenario 1- Net Zero
Fabric	£0/m²	£80/m²
Heating and ventilation	£0/m²	£34/m²
Renewable energy	£0/m²	-£5/m²
Total uplift	£0/m²	£108/m²
Total capital costs	£1,915/m²	£2,023/m²
% uplift in capital cost (current day)	-	5.6%

	Baseline	Scenario 1- Net Zero
Y1 Running cost	£647	£618
Y1 Running cost reduction compared to the baseline		4.5%
25 year running and maintenance cost	£14,452	£13,218
25 year running and maintenance cost compared to baseline		8.5%

Terrace house | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+6.8%

The adjacent table provides a summary of the specifications which were compared:

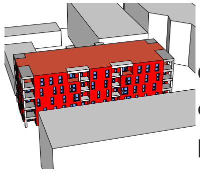
- The **baseline** scenario represents a home build in accordance with the Part L2021 notional building specification. This is based on a cost range in the top quartile of BCIS rates for houses for the period 2020-2024 and for includes a cost uplift of £55/m^2 over the base cost to allow for works to achieve Part L 2021 (enhanced roof insulation, windows and PV).
- **The additional construction cost of scenario 1 is estimated to be 6.8%.** Policy scenario 1 incorporates a higher standard of fabric energy efficiency, a more efficient MVHR system and the switch to a heat pump. The size of the solar PV array to meet the energy balance is slightly smaller than the requirements of the baseline, so this represents a cost saving.
- The 25 year running and maintenance cost of policy scenario 1 are 15% lower than the baseline.

	Baseline	Scenario 1- Net Zero
Fabric & ventilation	Part L 2021	Space heating demand limit
Heating	Gas boiler and waste-water heat recovery	Heat pump
Renewable energy on building	Part L baseline	To meet energy balance
	3.1 kWp	2.9 kWp

	Baseline	Scenario 1- Net Zero
Fabric	£0/m^2	£66/m^2
Heating and ventilation	£0/m^2	£46/m^2
Renewable energy	£0/m^2	-£2/m^2
Total uplift	£0/m^2	£111/m^2
Total capital costs	£1,635/m^2	£1,746/m^2
% uplift in capital cost (current day)	-	6.8%

	Baseline	Scenario 1- Net Zero
Y1 Running cost	£624	£551
Y1 Running cost reduction compared to the baseline		12%
25 year running and maintenance cost	£14,177	£12,107
25 year running and maintenance cost compared to baseline		15%

Mid-rise flats | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+5.4%

The adjacent table provides a summary of the specifications which were compared:

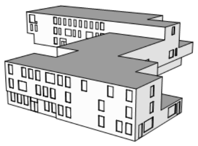
- The **baseline** scenario represents a home build in accordance with the Part L2021 notional building specification. This is based on a cost range in the mean range of BCIS rates for flats of 5-10 storeys for the period 2020-2024 with an allowance for contractors OHP and prelims. The rate also includes a cost uplift of £24/m^2 over the base cost to allow for works to achieve Part L2021 (enhanced roof insulation, windows and PV).
- **The additional construction cost of scenario 1 is estimated to be 5.4%.** Policy scenario 1 incorporates a higher standard of fabric energy efficiency, a more efficient MVHR system and photovoltaic panels.
- The costs for the Solar PV are split between the panels that fit on the roof, and panels that would need to be provided else ware, it has been assumed that this is on other roofs of buildings.
- The 25 year running and maintenance cost of policy scenario 1 are 39% lower than the baseline.

	Baseline	Scenario 1- Net Zero
Fabric & ventilation	Part L 2021	Space heating demand limit
Heating	Gas boiler and waste-water heat recovery	Heat pump
Renewable energy on building	Part L baseline	To meet energy balance
	15 kWp	84 kWp
Renewable energy on plot	0 kWp	37 kWp

	Baseline	Scenario 1- Net Zero
Fabric	£0/m^2	£46/m^2
Heating and ventilation	£0/m^2	£34/m^2
On building	£0/m^2	£19/m^2
Off building	£0/m^2	£8/m^2
Renewable energy - total	£0/m^2	£27/m^2
Total uplift	£0/m^2	£107/m^2
Total capital costs	£1,993/m^2	£2,100/m^2
% uplift in capital cost (current day)	-	5.4%

	Baseline	Scenario 1- Net Zero
Y1 Running cost	£1,091	£685
Y1 Running cost reduction compared to the baseline		37%
25 year running and maintenance cost	£25,365	£15,434
25 year running and maintenance cost compared to baseline		39%

School | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+5.3%

The adjacent table provides a summary of the specifications which were compared. The baseline specification is for a naturally ventilated building with passive extract / heat recovery systems while Scenario 1 includes for mechanical ventilation with heat recovery.

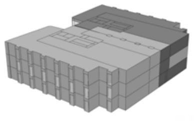
- The **baseline** scenario represents a school built in accordance with the Part L 2021 notional building specification with an air source heat pump. The baseline cost is derived from Currie & Brown's experience of delivering new school projects in Southern England.
- **The additional construction cost of scenario 1 is estimated to be 5.3%.** Policy scenario 1 incorporates a higher standard of fabric energy efficiency and photovoltaic panels.
- The costs for the Solar PV are split between the panels that fit on the roof, and panels that would need to be provided else ware, it has been assumed that this is on other roofs of buildings.
- The 25 year running and maintenance cost of policy scenario 1 are 85% lower than the baseline.

	Baseline	Scenario 1- Net Zero
Fabric & ventilation	Part L 2021	Space heating demand limit
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet energy balance
	0 kWp	328 kWp
Renewable energy on plot	0 kWp	96 kWp

	Baseline	Scenario 1- Net Zero
Fabric	£0/m^2	£131/m^2
Heating and ventilation	£0/m^2	£-4/m^2
On building	£0/m^2	£43/m^2
Off building	£0/m^2	£0/m^2
Renewable energy - total	£0/m^2	£43/m^2
Total uplift	£0/m^2	£170/m^2
Total capital costs	£3,200/m^2	£3,370/m^2
% uplift in capital cost (current day)	-	5.3%

	Baseline	Scenario 1- Net Zero
Y1 Running cost	£48,691	£8,812
Y1 Running cost reduction compared to the baseline		82%
25 year running and maintenance cost	£1,145,130	£167,388
25 year running and maintenance cost compared to baseline		85%

Office | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+2.7%

The adjacent table provides a summary of the specifications which were compared:

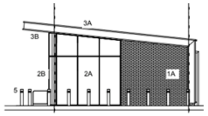
- The **baseline** scenario represents an office built in accordance with the Part L2021 notional building specification with an air source heat pump. The benchmark cost is based on a typical allowance for a large high-quality, air-conditioned office space.
- **The additional construction cost of scenario 1 is estimated to be 2.7%.** Policy scenario 1 incorporates a higher standard of fabric energy efficiency and photovoltaic panels.
- The costs for the Solar PV are split between the panels that fit on the roof, and panels that would need to be provided else ware, it has been assumed that this is on other roofs of buildings.
- The 25 year running and maintenance cost of policy scenario 1 are 67% lower than the baseline.

	Baseline	Scenario 1- Net Zero
Fabric & ventilation	Part L 2021	Space heating demand limit
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet energy balance
	0 kWp	198 kWp
Renewable energy on plot	0 kWp	141 kWp

	Baseline	Scenario 1- Net Zero
Fabric	£0/m^2	£24/m^2
Heating and ventilation	£0/m^2	-£20/m^2
On building	£0/m^2	£64/m^2
Off building	£0/m^2	£33/m^2
Renewable energy - total	£0/m^2	£97/m^2
Total uplift	£0/m^2	£101/m^2
Total capital costs	£3,745/m^2	£3,846/m^2
% uplift in capital cost (current day)	-	2.7%

	Baseline	Scenario 1- Net Zero
Y1 Running cost	£41,568	£14,636
Y1 Running cost reduction compared to the baseline		65%
25 year running and maintenance cost	£977,623	£320,181
25 year running and maintenance cost compared to baseline		67%

Retail | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+6.6%

The adjacent table provides a summary of the specifications which were compared:

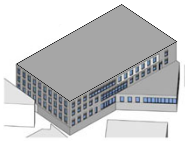
- The **baseline** scenario represents a retail building built in accordance with the Part L2021 notional building specification with an air source heat pump. The benchmark cost has been derived by Currie & Brown's quantity surveyors based on a typical allowance for a lightweight single storey retail unit.
- **The additional construction cost of scenario 1 is estimated to be 6.6%.** Policy scenario 1 incorporates a higher standard of fabric energy efficiency and photovoltaic panels.
- The 25 year running and maintenance cost of policy scenario 1 are 110% lower than the baseline. The building is a net exporter of electricity so the running and maintenance cost of policy scenario 1 is negative.

	Baseline	Scenario 1- Net Zero
Fabric & ventilation	Part L 2021	Space heating demand limit
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet energy balance
	0 kWp	17 kWp

	Baseline	Scenario 1- Net Zero
Fabric	£0/m²	£20/m²
Heating and ventilation	£0/m²	0/m²
Renewable energy	£0/m²	£72/m²
Total uplift	£0/m²	£93/m²
Total capital costs	£1,410/m²	£1,503/m²
% uplift in capital cost (current day)	-	6.6%

	Baseline	Scenario 1- Net Zero
Y1 Running cost	£1,947	-£105
Y1 Running cost reduction compared to the baseline		105%
25 year running and maintenance cost	£45,781	-£4,511
25 year running and maintenance cost compared to baseline		110%

Science and tech I Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+1.7%

The adjacent table provides a summary of the specifications which were compared:

- The **baseline** scenario represents a science & tech building built in accordance with the Part L2021 notional building specification with an air source heat pump. The benchmark cost has been derived by Currie & Brown's quantity surveyors based on a typical allowance for a large high-quality, air-conditioned science and technology building.
- **The additional construction cost of scenario 1 is estimated to be 1.7%.** Policy scenario 1 incorporates a higher standard of fabric energy efficiency and photovoltaic panels.
- The 25 year running and maintenance cost of policy scenario 1 are 133% lower than the baseline. The building is a net exporter of electricity, so the running and maintenance cost of policy scenario 1 is negative.

	Baseline	Scenario 1- Net Zero
Fabric & ventilation	Part L 2021	Space heating demand limit
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet energy balance
	0 kWp	338 kWp

	Baseline	Scenario 1- Net Zero
Fabric	£0/m^2	£44/m^2
Heating and ventilation	£0/m^2	£0/m^2
Renewable energy	£0/m^2	£49/m^2
Total uplift	£0/m^2	£102/m^2
Total capital costs	£5,900/m^2	£6,002/m^2
% uplift in capital cost (current day)	-	1.7%

	Baseline	Scenario 1- Net Zero
Y1 Running cost	£31,641	-£8,691
Y1 Running cost reduction compared to the baseline		127%
25 year running and maintenance cost	£744,143	-£245,413
25 year running and maintenance cost compared to baseline		133%

Weighted cost of Scenario 1 for domestic archetypes

Based on the following build mix proposed for the Salt Cross development a weighted cost impact of implementing Scenario 1has been estimated. All flats are assigned the £m^2 uplift cost for mid-rise flats, 2-3 bed houses are assigned the cost for the terraced house and 4-5 bed houses are assigned the cost of the detached house.

Unit type	Number
1 Bed flat	383
2 Bed flat	316
2 Bed house	326
3 Bed house	810
4 Bed house	252
5 Bed house	113
Total	2200

The weighted cost across the build mix is estimated at £109 per m^2 or 6.1% on top of the costs of a baseline home.

	Baseline cost	Additional cost of Scenario 1	Percentage uplift	Proportion of build mix	Weighted base cost	Weighted uplift cost	Weighted percentage uplift
Flats (1-2 bed)	£1,993	£107	5.4%	32%	£633	£34	5.4%
Terraced house (2-3 bed)	£1,635	£111	6.8%	52%	£844	£57	6.8%
Detached house (4-5 bed)	£1,915	£108	5.6%	17%	£318	£18	5.6%
				Weighted average	£1,795	£109	6.1%

Future capital cost

A projection of the future costs of implementing Scenario 1 in 2030 has been prepared based on the application of learning rates for key technologies.

Learning rates are used for key technologies that are not yet fully mature. Adjustment reflects a combination of global technology costs (eg from International Energy Agency and International Renewable Energy Agency) and local installer cost adjustments based on a first principles time and rates-based installation costs set against current market rates.

The table right summarises the impact of projected reductions in the future cost of meeting Scenario 1 based on projected learning for energy efficiency and low carbon technologies. Costs exclude any wider inflation, ie both costs are in 2024 prices.

Cost element	Percentage of 2024 cost
Photovoltaics	71%
Heat pump	75%
WWHR	81%
MVHR	93%
No learning	100%

	Policy scenario 1 cost in 2024	Policy scenario 1 cost in 2030	% reduction
Detached House	£112	£100	11%
Terrace House	£111	£93	16%
Mid-rise Flats	£107	£61	43%
School	£170	£158	7%
Office	£101	£77	24%
Retail	£93	£71	23%
Science & Tech	£102	£85	17%

Part 3

Scenario 2: Low Carbon Development

Technical and cost evidence base

Summary of policy scenario 2

Technical evidence base

Cost evidence base

3.1

Scenario 2: Low Carbon Development - Policy summary

Scenario 2: Low Carbon Development

1 Energy efficient fabric and ventilation

A minimum improvement over TFEE

All domestic buildings should achieve a minimum 10% improvement over TFEE. This should be evidenced through the use of Part L 2021 modelling.

2 Low total energy use

A minimum improvement over the TER.

All buildings should achieve a 100% reduction improvement over the TER. This should be evidenced through the use of Part L 2021 modelling.

3 Fossil fuel free

Yes

The building must not connect to the gas network or, more generally, use fossil fuels on-site. It must use a low carbon heating system (e.g. heat pump).

4 Onsite renewables

Buildings to maximise onsite renewables

Buildings should seek to generate as much renewable energy on the building as possible. If the amount needed to meet the TER improvement cannot be accommodated on the building, the additional capacity should be installed elsewhere on the plot.

5 Measurement and verification

Building data to be published

Post-occupancy energy monitoring should be carried out every year for the first five years of use of each building to understand the energy consumption of the development in-use. The results should be stored centrally and shared between developers, design teams and contractors on-site.

6 Overheating

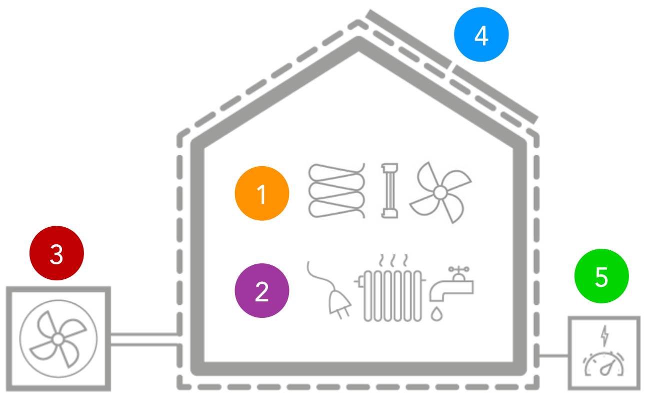
Overheating mitigation required

Residential buildings to comply with Part O of the Building Regulations. Non-residential buildings require compliance with CIBSE TM52.

7 Embodied carbon

Upfront carbon limit ($kgCO_2e/m^2_{GIA}$)

Development proposals will need to demonstrate attempts to reduce embodied carbon to meet the UK Net Zero carbon building standard upfront carbon limits.



Overheating, energy measurement, embodied carbon

Overheating

Modelling shall be undertaken to show compliance with Part O for residential and TM 52 for non-residential.

Where the energy efficiency of a building is improved and as the climate changes there is a greater risk of overheating in buildings. Overheating should be avoided though good design and mechanical cooling should only be included as a last resort.

At outline planning stage overheating should be mitigated through appropriate orientation and massing. A statement on the likely strategies that could be implemented at detailed planning stage should be covered.

At detailed planning stage the applicant should submit overheating calculations in line with the latest Part O or TM52 guidance, demonstrating that the homes are not expected to overheat.

Mitigation measures should be included where possible to prevent overheating in future climate scenarios. This may include the flexibility of designs to have future measures installed at a later date.

Design for the mitigation of overheating should be demonstrated as part of the outline planning submission. Overheating calculations should be carried out as part of the detailed planning submission and reconfirmed pre-commencement.

Embodied carbon

Development proposals will need to demonstrate attempts to reduce embodied carbon, to meet the upfront carbon limits the UK Net Zero Carbon Buildings Standard. (Building Life Cycle Stages A1-A5). Includes Substructure, Superstructure, MEP, Facade & Internal Finishes, excludes on site renewables.

As part of the submission of any planning application, a report should be prepared which demonstrates the calculation of the expected upfront embodied carbon of buildings. Full lifecycle modelling is encouraged.

Embodied carbon calculations should be carried out as part of the outline and detailed planning submission, be reconfirmed pre-commencement, and validated pre-occupation.

Measurement and verification

Meter, monitor and report on energy consumption and renewable energy generation post-completion for the first 5 years.

It is important that where buildings are designed to be energy efficient, with low carbon emissions, that they also perform to this standard when complete.

Applicants should confirm the metering, monitoring and reporting strategy as part of the detailed planning application. There should be a commitment to monitor consumption and report on it.

3.2

Technical evidence base

Summary of the modelling methodology and results

Technical and cost evidence base I The purpose of the energy and cost modelling analysis

Purpose of energy and cost modelling

The purpose of this modelling is to determine that Scenario 2 is:

a) Feasible from a technical perspective and to support the determination that they are also:

b) Has a cost uplift associated with it that feeds into the viability assessment.

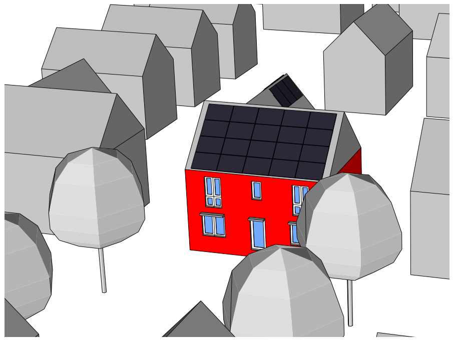
Energy modelling

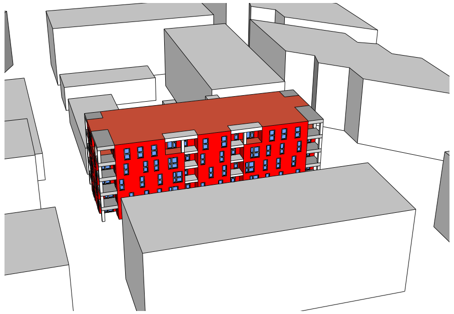
The energy modelling purpose is to investigate how different building archetypes perform against the metrics in Part L 2021 using specifications that achieve a defined improvement over building regulations compliance (Part L 2021). These results constitute the evidence that policy scenario 2 is technically achievable. The results are also used to inform the cost models and viability testing. modelling uses the climate file Severn valley, England. Solar radiation calculations for PV systems assume conditions in Oxford for accuracy. The modelling reflects the current weather. There are future weather files available which anticipate the warming expected in the medium term. These can be used to understand how the overheating risk may increase but are not used in Part L compliance modelling carried out in this study.

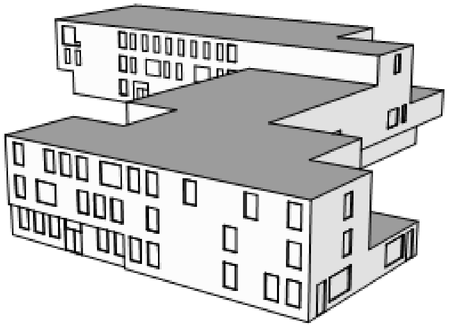
Cost modelling

The cost modelling estimates the additional cost a defined improvement over a baseline of building regulations compliance (Part L 2021). These results then have been used to inform policy viability assessments.

The cost modelling uses local cost indices.







3.2.1

Technical evidence base - Residential

Summary of the modelling methodology and results

Residential typologies

Selection of the typologies for modelling

To conduct the energy and cost modelling for this technical evidence base, a selection of domestic typologies was identified and assessed.

Given the diverse range of buildings in the district and the considerable variation within each building type, we have focused on three prominent types for residential houses: detached, terraced town house and mid-rise block of flats. These types were determined through discussions with the Council and analysis of recent planning applications. Specifications for each typology have been outlined (see adjacent images).

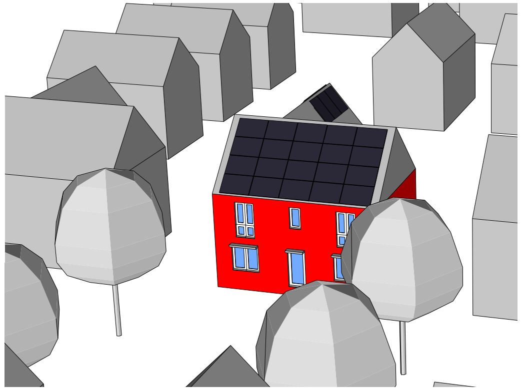
Part L energy modelling outputs

The buildings were modelled using SAP, to assess compliance with building regulations.

Detached House

A 4-bed detached house has been selected for modelling.

GIA: 141 m^2



Terraced Town House

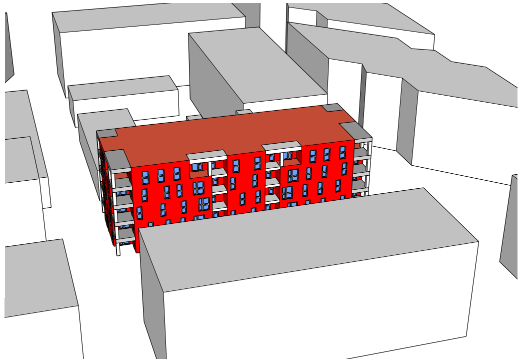
A 3-bed terraced town house has been proposed as a representative example and will be modelled with an additional unheated parking area below.

GIA: 101.5 m^2

Mid-rise block of flats

A 5-storeys block of flats has been selected for modelling.

GIA: 3,140 m^2 (whole building)



Residential typologies I Summary of Part L modelling results

The results show energy efficiency and carbon emission reduction potential across three residential building types: detached houses, terrace houses, and mid-rise blocks of flats.

The policy requirement of 10% improvement over the TFEE can be achieved based on enhanced building fabric.

For the architypes modelled, the fabric efficiency improvements exceed the policy requirement. This shows that the policy is technically feasible.

The policy requirement of 100% regulated carbon emission reductions can be achieved based on enhanced fabric and systems efficiency and Solar PV panels on the roof of the building for the detached house and the terraced house.

For the mid-rise block of flats, due to the number of storeys of the building 100% regulated carbon emission reductions can't be achieved based on enhanced fabric and systems efficiency and Solar PV panels on the roof alone, additional solar PV panels are required to be provided elsewhere on the plot, such as on other roofs of buildings (such as detached homes, where there is space on the roof for additional PV beyond meeting 100% carbon emissions for the detached home itself), or solar PV could be integrated into the facade, or provided on top of car parking spaces, or elsewhere onsite.

These results highlight the varying effectiveness of energy efficiency measures and PV integration across different residential building types.

	Detached House	Terrace House	Mid-rise block of Flats
Fabric efficiency improvement **% DFEE < TFEE**	10%	14%	20%
Can the Fabric efficiency limit be met	✓	✓	✓
PV required to meet 100% regulated carbon emission reductions for Part L (kW)	4.1 kWp	6.7 kWp	106.0 kWp
PV area required to meet 100% regulated carbon emission reductions for Part L (m^2)	20 m^2	35 m^2	514 m^2
Can 100% regulated carbon emission reductions be achieved on the building?	✓	✓	✗ No-80% is the maximum as 106 kWp does not fit on the roof
Solar PV area required on plot to meet policy (m^2) in addition to the Solar PV on the roof	-	-	138 m^2

3.2.2

Technical evidence base - Non residential

Summary of the modelling methodology and results

Non-residential typologies

Before presenting the extensive results of these analyses, this section summarises our general approach to energy and cost modelling, providing a coherent framework for understanding the impacts and benefits of policy scenario 2.

Selection of the typologies for modelling

To conduct the energy and cost modelling for this technical evidence base, a selection of non-domestic typologies was identified and assessed.

Given the diverse range of buildings in the district and the considerable variation within each building type, we have focused on four prominent types for non-residential buildings: School, office, Science and tech building and Community retail. These types were determined through discussions with the Council and analysis of recent planning applications. Specifications for each typology have been outlined (see adjacent images).

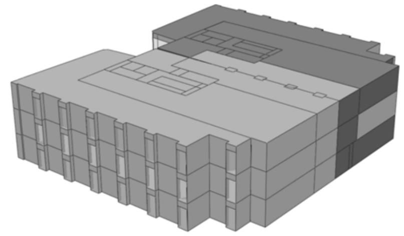
Part L energy modelling outputs

The buildings were modelled using a Part L modelling tools. The office was modelled in IESVE and the School was modelled in TAS.

Office

The images here represent the 3-storey office block that has been selected for modelling.

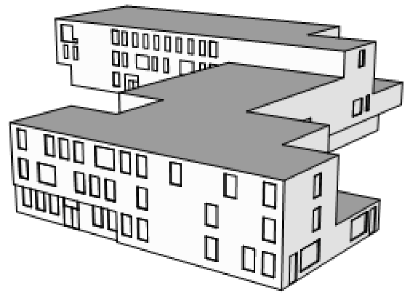
GIA: 4000 m^2



School

A representative secondary school with 3-4 stories, additional changing and IT space

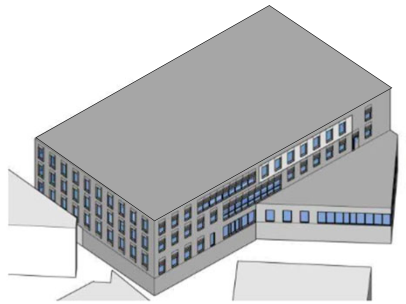
GIA: 6000 m^2



Science and Technology

A 3-storey simple block with 60% labs and the remainder as ancillary space has been selected for modelling.

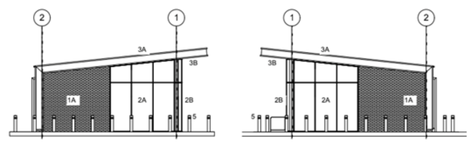
GIA: 5,000 m^2 (max height 13m)



Retail

A single storey retail unit has been selected for modelling.

GIA: 274m^2



Non-residential typologies I Summary of Part L modelling results

The results show energy carbon emission reduction potential across four non-residential building types: School, office, retail and science and technology.

Part L does not have a non-residential fabric energy efficiency rating, thus the fabric efficiency improvement is not applicable for no-residential developments.

The policy requirement of 100% regulated carbon emission reductions can be achieved based on enhanced fabric and systems efficiency and Solar PV panels on the roof of the building.

The table to the right shows the carbon emission reductions without Solar PV. All of the building types require Solar PV to meet the policy.

The table also shows the maximum amount of Solar PV that fits on the building, which shows that it is technically feasible to achieve more Solar PV on the building than the requirements of the policy.

	School	Office	Retail	Science & Technology
Fabric efficiency improvement % DFEE < TFEE	n/a	n/a	n/a	n/a
Can the Fabric efficiency limit be met	n/a	n/a	n/a	n/a
PV required to meet 100% regulated carbon emission reductions for Part L (kW)	185 kWp	168 kWp	10 kWp	153 kWp
PV area required to meet 100% regulated carbon emission reductions for Part L (m^2)*	800 m^2	727 m^2	43 m^2	663 m^2
Can 100% regulated carbon emission reductions be achieved on the building?	✓	✓	✓	✓

* Calculation assumes a 450W panel

3.3

Cost evidence base

Summary of the modelling methodology and results

Cost analysis summary

The cost analysis was carried out to inform the viability assessment that will be carried out.

A summary of the cost analysis is shown to the right.

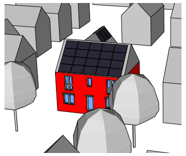
The capital cost uplift of policy scenario 2 is 1.3%-5.6% higher than the baseline, aside from the Terrace house that has a cost increase of 8.9%, this is in part due to a large Solar PV array.

As always with costs, it is important to understand how these assessments were undertaken as well as their limitations. In particular, the costs models are based on the buildings modelled. Although the trends and scale are expected to be similar for other buildings within the same archetype, variations are possible. This is particularly the case for housing where different developer sizes, specifications and delivery models will influence costs.

	Capital Costs	Running Costs
Detached House	+4.4%	+ 4%
Terrace House	+8.9%	- 89%
Mid-rise Flats	+5.6%	- 78%
School	+2.2%	- 44%
Office	+1.7%	- 58%
Retail	+4.5%	- 69%
Science & Tech	+1.3%	- 38%

Summary of uplift in total capital costs and percentage reduction of 25 year running and maintenance cost compared to baseline

Detached house | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+4.4%

The adjacent table provides a summary of the specifications which were compared:

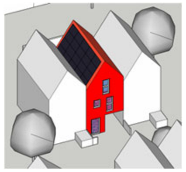
- The **baseline** scenario represents a home build in accordance with the Part L2021 notional building specification. This is based on a cost range in the top quartile of BCIS rates for houses for the period 2020-2024 and for includes a cost uplift of £48/m^2 over the base cost to allow for works to achieve Part L2021 (enhanced roof insulation, windows and PV).
- **The additional construction cost of scenario 2 is estimated to be 4.4%.** policy scenario 2 incorporates a higher standard of fabric energy efficiency, a more efficient MVHR system and the switch to a heat pump. The size of the solar PV array to meet 100% carbon emission reductions is slightly smaller than the baseline, so this represents a cost saving.
- The 25 year running and maintenance cost of policy scenario 2 are 4% higher than the baseline, this is due to the smaller PV array and the fact that meeting the 10% fabric efficiency requirement for the detached house is not that difficult, if the fabric were further improved the running costs would be lower.

	Baseline	Scenario 2 – Low carbon
Fabric & ventilation	Part L 2021	Meeting 10% reduction of FEES
Heating	Gas boiler and waste-water heat recovery	Heat pump
Renewable energy	Part L baseline	To meet 100% regulated carbon emission reductions
	4.8 kWp	4.1 kWp

	Baseline	Scenario 2 – Low carbon
Fabric	£0/m^2	£55/m^2
Heating and ventilation	£0/m^2	£34/m^2
Renewable energy	£0/m^2	-£5/m^2
Total uplift	£0/m^2	£84/m^2
Total capital costs	£1,915/m^2	£1,999/m^2
% uplift in capital cost (current day)	-	4.4%

	Baseline	Scenario 2 – Low carbon
Y1 Running cost	£647	£701
Y1 Running cost reduction compared to the baseline		-8% (increase)
25 year running and maintenance cost	£14,452	£15,026
25 year running and maintenance cost compared to baseline		-4% (increase)

Terrace house | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+8.9%

The adjacent table provides a summary of the specifications which were compared:

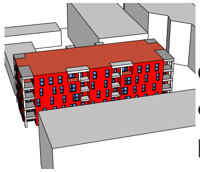
- The **baseline** scenario represents a home build in accordance with the Part L2021 notional building specification. This is based on a cost range in the top quartile of BCIS rates for houses for the period 2020-2024 and for includes a cost uplift of £48/m^2 over the base cost to allow for works to achieve Part L2021 (enhanced roof insulation, windows and PV).
- **The additional construction cost of scenario 2 is estimated to be 8.9%.** It incorporates a higher standard of fabric energy efficiency, a more efficient MVHR system, the switch to a heat pump and a larger solar PV array.
- The 25 year running and maintenance cost of policy scenario 2 are 89% lower than the baseline.

	Baseline	Scenario 2 – Low carbon
Fabric & ventilation	Part L 2021	Meeting 10% reduction of FEES
Heating	Gas boiler and waste-water heat recovery	Heat pump
Renewable energy	Part L baseline	To meet 100% regulated carbon emission reductions
	3.1 kWp	6.7 kWp

	Baseline	Scenario 2 – Low carbon
Fabric	£0/m^2	£66
Heating and ventilation	£0/m^2	£46
Renewable energy	£0/m^2	£33
Total uplift	£0/m^2	£146/m^2
Total capital costs	£1,635/m^2	£1,781/m^2
% uplift in capital cost (current day)	-	8.9%

	Baseline	Scenario 2 – Low carbon
Y1 Running cost	£624	£110
Y1 Running cost reduction compared to the baseline		82%
25 year running and maintenance cost	£14,177	£1,603
25 year running and maintenance cost compared to baseline		89%

Mid-rise flats | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+5.6%

The adjacent table provides a summary of the specifications which were compared:

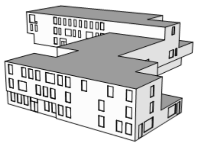
- The **baseline** scenario represents a home build in accordance with the Part L2021 notional building specification. This is based on a cost range in the mean range of BCIS rates for flats of 5-10 storeys for the period 2020-2024 with an allowance for contractors OHP and prelims. The rate also includes a cost uplift of £24/m² over the base cost to allow for works to achieve Part L2021 (enhanced roof insulation, windows and PV).
- **The additional construction cost of scenario 2 is estimated to be 5.6%.** It incorporates a higher standard of fabric energy efficiency, a more efficient MVHR system and photovoltaic panels.
- The costs for the Solar PV are split between the panels that fit on the roof, and panels that would need to be provided else ware, it has been assumed that this is on other roofs of buildings.
- The 25 year running and maintenance cost of policy scenario 2 are 78% lower than the baseline.

	Baseline	Scenario 2 – Low carbon
Fabric & ventilation	Part L 2021	Meeting 10% reduction of FEES
Heating	Gas boiler and waste-water heat recovery	Heat pump
Renewable energy	Part L baseline	To meet 100% regulated carbon emission reductions
	15 kWp	80 kWp
Renewable energy on plot	0 kWp	26 kWp

	Baseline	Scenario 2 – Low carbon
Fabric	£0/m²	£43/m²
Heating and ventilation	£0/m²	£34/m²
On building	£0/m²	£21/m²
Off building	-	£11/m²
Renewable energy - total	£0/m²	£32/m²
Total uplift	£0/m²	£112/m²
Total capital costs	£1,993/m²	£2,105
% uplift in capital cost (current day)	-	5.6%

	Baseline	Scenario 2 – Low carbon
Y1 Running cost	£1,091	£223
Y1 Running cost reduction compared to the baseline		80%
25 year running and maintenance cost	£25,365	£5,566
25 year running and maintenance cost compared to baseline		78%

School | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+2.2%

The adjacent table provides a summary of the specifications which were compared. Both the baseline and scenario 2 specifications are for a naturally ventilated building with passive extract / heat recovery systems.

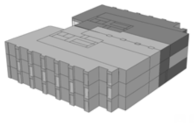
- The **baseline** scenario represents a school built in accordance with the Part L 2021 notional building specification with an air source heat pump. The baseline cost is derived from Currie & Brown's experience of delivering new school projects in Southern England.
- **The additional construction cost of scenario 2 is estimated to be 2.2%.** It incorporates a higher standard of fabric energy efficiency and photovoltaic panels.
- The 25-year running, and maintenance cost of policy scenario 2 are 44% lower than the baseline.

	Baseline	Scenario 2 – Low carbon
Fabric & ventilation	Part L 2021	Meeting 10% reduction of FEES
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet 100% regulated carbon emission reductions
	0 kWp	185 kWp

	Baseline	Scenario 2 – Low carbon
Fabric	£0/m^2	£32/m^2
Heating and ventilation	£0/m^2	£0/m^2
Renewable energy	£0/m^2	£37/m^2
Total uplift	£0/m^2	£70/m^2
Total capital costs	£3,200/m^2	£3,270/m^2
% uplift in capital cost (current day)		2.2%

	Baseline	Scenario 2 – Low carbon
Y1 Running cost	£48,691	£27,862
Y1 Running cost reduction compared to the baseline		43%
25 year running and maintenance cost	£1,145,130	£635,753
25 year running and maintenance cost compared to baseline		44%

Office | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+1.7%

The adjacent table provides a summary of the specifications which were compared:

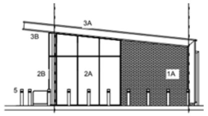
- The **baseline** scenario represents an office built in accordance with the Part L2021 notional building specification with an air source heat pump. The benchmark cost has been derived by Currie & Brown's quantity surveyors based on a typical allowance for a large high-quality, air-conditioned office space.
- **The additional construction cost of scenario 2 is estimated to be 1.7%.** It incorporates a higher standard of fabric energy efficiency, heat recovery mechanical ventilation and photovoltaic panels.
- The 25 year running and maintenance cost of policy scenario 2 are 58% lower than the baseline.

	Baseline	Scenario 2 – Low carbon
Fabric & ventilation	Part L 2021	Meeting 10% reduction of FEES
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet 100% regulated carbon emission reductions
	0 kWp	168 kWp

	Baseline	Scenario 2 – Low carbon
Fabric	£0/m²	£24/m²
Heating and ventilation	£0/m²	0/m²
Renewable energy	£0/m²	£40/m²
Total uplift	£0/m²	£64/m²
Total capital costs	£3,745/m²	£3,808/m²
% uplift in capital cost (current day)	-	1.7%

	Baseline	Scenario 2 – Low carbon
Y1 Running cost	£41,568	£18,210
Y1 Running cost reduction compared to the baseline		56%
25 year running and maintenance cost	£977,623	£407,894
25 year running and maintenance cost compared to baseline		58%

Retail | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+4.5%

The adjacent table provides a summary of the specifications which were compared:

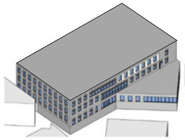
- The **baseline** scenario represents a retail building built in accordance with the Part L2021 notional building specification with an air source heat pump. The benchmark cost has been derived by Currie & Brown's quantity surveyors based on a typical allowance for a lightweight single storey retail unit.
- **The additional construction cost of scenario 2 is estimated to be 4.5%.** It incorporates a higher standard of fabric energy efficiency and photovoltaic panels.
- The 25 year running and maintenance cost of policy scenario 2 are 69% lower than the baseline.

	Baseline	Scenario 2 – Low carbon
Fabric & ventilation	Part L 2021	Meeting 10% reduction of FEES
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet 100% regulated carbon emission reductions
	0 kWp	10.1 kWp

	Baseline	Scenario 2 – Low carbon
Fabric	£0/m^2	£20/m^2
Heating and ventilation	£0/m^2	0/m^2
Renewable energy	£0/m^2	£44/m^2
Total uplift	£0/m^2	£64/m^2
Total capital costs	£1,410/m^2	£1,474/m^2
% uplift in capital cost (current day)	-	4.5%

	Baseline	Scenario 2 – Low carbon
Y1 Running cost	£1,947	£650
Y1 Running cost reduction compared to the baseline		67%
25 year running and maintenance cost	£45,781	£14,032
25 year running and maintenance cost compared to baseline		69%

Science and tech | Cost modelling



Combined impact on construction cost of proposed policy compared to baseline

+1.3%

to baseline

The adjacent table provides a summary of the specifications which were compared:

- The **baseline** scenario represents a science & tech building built in accordance with the Part L2021 notional building specification with an air source heat pump. The benchmark cost has been derived by Currie & Brown's quantity surveyors based on a typical allowance for a large high-quality, air-conditioned science and technology building.
- **The additional construction cost of scenario 2 is estimated to be 1.3%.** It incorporates a higher standard of fabric energy efficiency and photovoltaic panels.
- The 25 year running and maintenance cost of policy scenario 2 are 38% lower than the baseline.

	Baseline	Scenario 2 – Low carbon
Fabric & ventilation	Part L 2021	Meeting 10% reduction of FEES
Heating	Heat pump	Heat pump
Renewable energy	Part L baseline	To meet 100% regulated carbon emission reductions
	0 kWp	153 kWp

	Baseline	Scenario 2 – Low carbon
Fabric	£0/m²	£44/m²
Heating and ventilation	£0/m²	£0/m²
Renewable energy	£0/m²	£32/m²
Total uplift	£0/m²	£76/m²
Total capital costs	£5,900/m²	£5,976/m²
% uplift in capital cost (current day)	-	1.3%

	Baseline	Scenario 2 – Low carbon
Y1 Running cost	£31,641	£19,969
Y1 Running cost reduction compared to the baseline		37%
25 year running and maintenance cost	£744,143	£457,820
25 year running and maintenance cost compared to baseline		38%

Weighted cost of policy scenario 2 for domestic archetypes

Based on the following build mix proposed for the Salt Cross development a weighted cost impact of implementing scenario 2 has been estimated. All flats are assigned the £m^2 uplift cost for mid-rise flats, 2-3 bed houses are assigned the cost for the terraced house and 4-5 bed houses are assigned the cost of the detached house.

Unit type	Number
1 Bed flat	383
2 Bed flat	316
2 Bed house	326
3 Bed house	810
4 Bed house	252
5 Bed house	113
Total	2200

The weighted cost across the build mix is estimated at £125 per m^2 or 7.0% on top of the costs of a baseline home.

	Baseline cost	Additional cost of Scenario 2	Percentage uplift	Proportion of build mix	Weighted base cost	Weighted uplift cost	Weighted percentage uplift
Flats (1-2 bed)	£1,993	£112	5.6%	32%	£633	£36	5.6%
Terraced house (2-3 bed)	£1,635	£146	8.9%	52%	£844	£75	8.9%
Detached house (4-5 bed)	£1,915	£84	4.4%	17%	£318	£14	4.4%
				Weighted average	£1,795	£125	7.0%

Future capital cost

A projection of the future costs of implementing Scenario 2 in 2030 has been prepared based on the application of learning rates for key technologies.

Learning rates are used for key technologies that are not yet fully mature. Adjustment reflects a combination of global technology costs (eg from International Energy Agency and International Renewable Energy Agency) and local installer cost adjustments based on a first principles time and rates-based installation costs set against current market rates.

The table right summarises the impact of projected reductions in the future cost of meeting Scenario 2 based on projected learning for energy efficiency and low carbon technologies. Costs exclude any wider inflation, ie both costs are in 2024 prices.

Cost element	Percentage of 2024 cost
Photovoltaics	71%
Heat pump	75%
WWHR	81%
MVHR	93%
No learning	100%

	Policy scenario 2 cost in 2024	Policy scenario 2 cost in 2030	% reduction
Detached House	£43	£30	29%
Terrace House	£146	£118	19%
Mid-rise Flats	£112	£65	42%
School	£70	£59	16%
Office	£64	£52	18%
Retail	£64	£51	21%
Science & Tech	£76	£67	12%

Performance targets for non modelled typologies

Energy and cost modelling has been undertaken in this evidence base in order to cover a range of different types of buildings. This modelling has been used to confirm the technical feasibility of meeting a 100% TER improvement and associated PV generation requirements.

There are a few typologies for which modelling has not been completed because the variability of use within the typology is extremely wide. It is recommended for these typologies that policy is based on a 100% TER improvement, with recognition that there may need to be some provision of PV other than on the building in some cases and flexibility to consider where applicants can show that meeting this requirement is not feasible.

Appendices

Appendix A
Case Studies

Case studies – Houses

Image source: Google maps

Burnham Overy Stainthein, Norfolk

Building typology: terrace houses
Architect: Parsons + Whittley
No. of homes: 3
Completion: 2014

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas
- Passivhaus certified

Exterior wall U-value: 0.10 W/m²K
Ground floor U-value: 0.08 W/m²K
Roof U-value: 0.08 W/m²K
Window U-value: 0.93 W/m²K
Window g-value: 0.61
Airtightness: 0.64 ac/h

Image source: Google maps

Hanham Hall, Bristol, Gloucestershire

Building typology: semi-detached, terrace houses and low-rise apartments
Architect: HTA Architects
No. of homes: 185
Completion: 2016

Low carbon design strategies:

- Simplified design form
- Shading strategy to reduce overheating

Exterior wall U-value: 0.18 W/m²K
Ground floor U-value: 0.11 W/m²K
Window U-value: >1.00 W/m²K
Airtightness: 0.56 ac/h

Gas boiler

Image source: Stonewoodhomes

Elm Grove, Nailsea, North Somerset

Building typology: houses
Architect: Mikhail Riches
No. of homes: 52
Completion: 2024

Low carbon design strategies:

- South-facing orientation
- Simplified design form
- Optimised glazing areas

Exterior wall U-value: 0.11 W/m²K
Ground floor U-value: 0.07 W/m²K
Roof U-value: 0.09 W/m²K
Window U-value: ≤0.8 W/m²K
Airtightness: 0.6 ac/h

Image source: TateHindle

Deben fields, Felixstowe, East Suffolk

Building typology: houses and low-rise apartments
Architect: TateHindle
No. of homes: 16 +45
Under construction

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas
- Shading strategy to reduce overheating

Exterior wall U-value: ≤0.15 W/m²K
Ground floor U-value: ≤0.11 W/m²K
Roof U-value: ≤0.10 W/m²K
Window U-value: ≤0.8 W/m²K
Airtightness: ≤60 ac/h

Case studies – Houses

Image source: Google maps

Carrowbreck Meadow development, Norwich

Building typology: detached houses
Architect: Hamson Barron Smith
No. of homes: 14
Completion: 2016

Low carbon design strategies:

- South-facing orientation
- Simplified design form
- Optimised glazing areas

Exterior wall U-value: 0.10 W/m²K
Ground floor U-value: 0.11 W/m²K
Roof U-value: 0.09 W/m²K
Window U-value: 0.80 W/m²K
Window g-value: 0.59
Airtightness: 0.45 ac/h

Gas boiler

Image source: Google maps

Essex Village Wimbish II, Wimbish, Essex

Building typology: semi-detached houses
Architect: Parsons + Whittley
No. of homes: 11
Completion: 2018

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas

Exterior wall U-value: 0.12 W/m²K
Ground floor U-value: 0.10 W/m²K
Roof U-value: 0.09 W/m²K
Window U-value: 0.73 W/m²K
Window g-value: 0.50
Airtightness: 0.60 ac/h

Gas boiler

Image source: Google maps

Standings Court development, Horsham, West Sussex

Building typology: terrace houses
Architect: MH Architects
No. of homes: 12
Completion: 2012

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas

Exterior wall U-value: 0.11 W/m²K
Ground floor U-value: 0.11 W/m²K
Roof U-value: 0.08 W/m²K
Window U-value: 1.0 W/m²K
Window g-value: 0.45
Airtightness: 0.60 ac/h

Gas boiler

Image source: Levitt Bernstein

Goldsmith St, Norwich

Building typology: terrace houses
Architect: Mikhail Riches
No. of homes: 93
Completion: 2019

Low carbon design strategies:

- North/south-facing homes
- Simplified design form – long terrace
- Optimised glazing areas
- Design for reduced overshadowing

Exterior wall U-value: 0.11 W/m²K
Ground floor U-value: 0.08 W/m²K
Roof U-value: 0.10 W/m²K
Window U-value: 0.92 W/m²K
Window g-value: 0.51
Airtightness: 0.60 ac/h

Gas boiler

Case studies – Block of apartments

Image source: [Anne Thorne Architects]

Cannock Mill Co-housing, Colchester, Essex

Building typology: low-rise block of flats (2 storeys)
Architect: Anne Thorne Architects LLP
No. of homes: 6
Completion: 2019

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas
- Passivhaus certified

Exterior wall U-value: 0.10 W/m²K
Ground floor U-value: 0.12 W/m²K
Roof U-value: 0.08 W/m²K
Window U-value: 0.90 W/m²K
Airtightness: 0.60 ac/h

Gas boiler

Image source: Google maps

Knights Place, Exeter, Devon

Building typology: low-rise block of flats (3 storeys)
Architect: Gale & Snowden
No. of homes: 18
Completion: 2010

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas
- Passivhaus certified

Exterior wall U-value: 0.12 W/m²K
Ground floor U-value: 0.17 W/m²K
Roof U-value: 0.09 W/m²K
Window U-value: 0.09 W/m²K
Window g-value: 0.50
Airtightness: 0.60 ac/h

Image source: Google maps

Chester Long Court, Whipton, Exeter

Building typology: low-rise block of apartments (3-4-storeys)
Architect: Gale & Snowden
No. of homes: 26
Completion: 2018

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas
- Shading strategy to reduce overheating
- Passivhaus certified

Exterior wall U-value: 0.23 W/m²K
Ground floor U-value: 0.10 W/m²K
Roof U-value: 0.07 W/m²K
Window U-value: 1.00 W/m²K
Airtightness: 0.60 ac/h

Gas boilers

Image source: Levitt Bernstein

Plashet Road, Newham, London

Building typology: low and mid-rise block of flats (4-5 storeys)
Architect: Levitt Bernstein
No. of homes: 65
Completion: 2024

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas

Exterior wall U-value: 0.15 W/m²K
Ground floor U-value: 0.11 W/m²K
Roof U-value: 0.10 W/m²K
Window U-value: <1.00 W/m²K
Window g-value: 0.53
Airtightness: 0.60 ac/h

Case studies – Commercial

Image source: Kellogg

Image source: Passivhaus Trust

Image source: Passive House+

Image source: Architype

Kellogg College Hub, Oxford

Building typology: café and social space
Architect: Fielden Clegg Bradley Studios
Completion: 2017

Low carbon design strategies:

- South-facing orientation
- Simplified design form
- Shading strategy to reduce overheating

Exterior wall U-value: 0.08 W/m^2K
Ground floor U-value: 0.14 W/m^2K
Roof U-value: 0.06 W/m^2K
Window U-value: 0.88 W/m^2K
Window g-value: 0.53
Airtightness: 0.60 ac/h

Gas boiler

Black Barns Office, Guyhirn, Wisbech

Building typology: office
Architect: Swann Edwards Architecture
Completion: 2018

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas
- Shading strategy to reduce overheating

Exterior wall U-value: 0.13 W/m^2K
Ground floor U-value: ≤0.11 W/m^2K
Roof U-value: 0.12 W/m^2K
Window U-value: 0.7 W/m^2K
Airtightness: 0.4 ac/h

Interserve Office, Syston, Leicester

Building typology: office
Architect: CPMG
Completion: 2011

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas

Exterior wall U-value: 0.11-0.12 W/m^2K
Ground floor U-value: 0.13 W/m^2K
Roof U-value: 0.13 W/m^2K
Window U-value: 0.80 W/m^2K
Airtightness: 0.44 ac/h

Bicester Eco Business Centre, Bicester

Building typology: co-working spaces
Architect: Architype
Completion: 2018

Low carbon design strategies:

- Simplified design form
- Optimised glazing areas
- Shading strategy to reduce overheating

Exterior wall U-value: 0.14 W/m^2K
Ground floor U-value: 0.13 W/m^2K
Roof U-value: 0.09 W/m^2K
Window U-value: 0.72 W/m^2K
Window g-value: 0.5
Airtightness: 3 ac/h

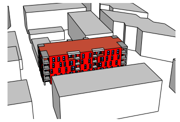
Gas district system

Appendix B
Modelling Specifications

Assumptions

Residential typologies I Assumptions

This table summarises the different energy efficiency assumptions modelled.

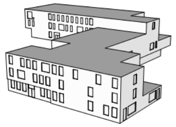


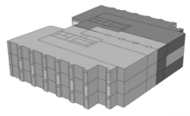
		Detached house		Terrace house		Mid-rise block of flats	
		Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled
Fabric	Floor U-value (W/m^{2}K)	0.15	0.10	0.13	0.10	0.15	0.13
	External wall U-value (W/m^{2}K)	0.15	0.12	0.16	0.12	0.16	0.15
	Roof U-value (W/m^{2}K)	0.11	0.10	0.10	0.10	0.15	0.10
	Window U-value (W/m^{2}K)	1.20	0.80	1.2	0.80	1.20	0.80
	Doors (W/m^{2}K)	1	1	1	1	1	1
	Thermal bridge allowance (kWh/m^2/yr)	5	3	5	3	5	3
	Air permeability (m^3/m^2.h)	5	1	5	1	5	1.2
Systems	Ventilation	Natural ventilation with intermittent extract fans	90% MVHR <2m external duct 25mm insulation	Natural ventilation with intermittent extract fans	90% MVHR <2m external duct 25mm insulation	Natural ventilation with intermittent extract fans	90% MVHR <2m external duct 25mm insulation
	MVHR specific fan power	0.15 W/m^3/h	0.24 W/m^3/h	0.15 W/m3/h	0.24 W/m^3/h	0.15 W/m^3/h	0.24 W/m^3/h
	Space Heating	Gas combi boiler	ASHP	Gas combi boiler	ASHP	Gas combi boiler	Ambient loop ASHP
		Radiators > 60˚C	Radiators < 45˚C	Radiators > 60˚C	Radiators < 45˚C	Radiators > 60˚C	Radiators < 45˚C
		7kW	5kW	3kW	5kW	3kW	2kW
		Efficiency - 89%	COP - 3.5	Efficiency - 89%	COP - 3.5	Efficiency - 89%	COP - 3.5
	DHW tank size	None	200L	None	200L	None	200L
	WWHR efficiency	36%	No WWHR	36%	No WWHR	36%	No WWHR

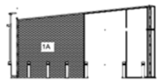
Note: For the cost modeling the specifications for the notional building was used for the baseline.

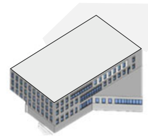
Non-residential typologies I Assumptions

This table summarises the different energy efficiency assumptions modelled.





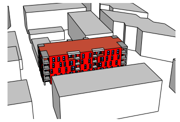




		School		Office		Retail		Science & Tech	
		Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled
Fabric	Floor U-value (W/m^{2}K)	0.18	0.12	0.18	0.12	0.15	0.12	0.18	0.12
	External wall U-value (W/m^{2}K)	0.26	0.18	0.26	0.18	0.18	0.18	0.26	0.13
	Roof U-value (W/m^{2}K)	0.18	0.13	0.18	0.13	0.15	0.13	0.18	0.11
	Window U-value (W/m^{2}K)	1.6	1.2	1.6	1.4	1.4	1.4	1.6	1
	Doors (W/m^{2}K)	1.6	1.6	1.9	1.5	1.9	1.5	1.6	1
	Thermal bridge allowance (kWh/m^2/yr)	Part L defaults	Part L defaults	10% of losses	3% of losses	10% of losses	3% of losses	10% of losses	3% of losses
	Air permeability (m^3/m^2.h)	3	3	3	3	3	3	3	3
	Ventilation	70% MVHR <2m external duct 25mm insulation	70% MVHR <2m external duct 25mm insulation	AHU with 76% HR	AHU with 80% HR	AHU with 76% HR	AHU with 80% HR	AHU with 76% HR	AHU with 80% HR
Systems	MVHR specific fan power (SAP)	1.6 W/l/s	1.6 W/l/s	1.8 W/l/s	1.6 W/l/s	1.8 W/l/s	1.6 W/l/s	1.6 W/l/s	1.6 W/l/s
	Space Heating	Heat pump	Heat pump	Heat pump	Heat pump	Heat pump (VRF)	Heat pump (VRF)	Heat pump	Heat pump
		Radiators < 45˚C	Radiators < 45˚C	FCU	FCU	Radiators < 45˚C	Radiators < 45˚C	FCU	FCU
	Domestic Hot Water system	COP - 2.5	COP - 3.5 to 4.0	FCUs – 2.5 COP	FCUs – 3.5	VRF COP - 2.5	VRF COP - 3.5 to 4.0	COP - 2.5	COP - 3.5 to 4.0
	Weather compensation?	Weather comp - Yes	Weather comp - Yes	Weather comp - Yes	Weather comp - Yes	Weather comp - Yes	Weather comp - Yes	Weather comp - Yes	Weather comp - Yes
	Cooling efficiency	n/a	n/a	SEER 4.4	SEER 5	SEER 3	SEER 5	SEER 3	SEER 5
	Domestic hot water efficiency	Direct electric point-of-use hot water	Direct electric point-of-use hot water	DE to toilets A 1000L hot water store for the showers fed by a heat pump	DE to toilets A 400L hot water store for the showers fed by a heat pump	Direct electric point-of-use hot water	Direct electric point-of-use hot water	Direct electric point-of-use hot water	Direct electric point-of-use hot water
	DHW storage size	n/a	n/a	1000L	400L	n/a	n/a	n/a	n/a

Residential typologies I Assumptions

This table summarises the different energy efficiency assumptions modelled.

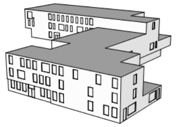


		Detached house		Terrace house		Mid-rise block of flats	
		Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled
Fabric	Floor U-value (W/m^2K)	0.15	0.10	0.13	0.10	0.15	0.13
	External wall U-value (W/m^2K)	0.15	0.12	0.16	0.12	0.16	0.15
	Roof U-value (W/m^2K)	0.11	0.10	0.10	0.10	0.15	0.10
	Window U-value (W/m^2K)	1.20	1.2	1.2	0.80	1.20	0.80
	Doors (W/m^2K)	1	1	1	1	1	1
	Thermal bridge allowance ($kWh/m^2/yr$)	5	5	5	3	5	3
	Air permeability ($m^3/m^2.h$)	5	3	5	1	5	1.2
Systems	Ventilation	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	90% MVHR <2m external duct 25mm insulation	Natural ventilation with intermittent extract fans	90% MVHR <2m external duct 25mm insulation
	Specific fan power (SAP)	Default	0.7 W/l/s	Default	0.7 W/l/s	Default	0.7 W/l/s
	Space Heating	Gas combi boiler	ASHP	Gas combi boiler	ASHP	Gas combi boiler	Ambient loop ASHP
		Radiators > 60˚C	Radiators < 45˚C	Radiators > 60˚C	Radiators < 45˚C	Radiators > 60˚C	Radiators < 45˚C
		7kW	7kW	3kW	5kW	3kW	2kW
		Efficiency - 89%	COP - 3.5	Efficiency - 89%	COP - 3.5	Efficiency - 89%	COP - 3.5
	Domestic Hot Water system	None	Hot water storage cylinder	None	Hot water storage cylinder	None	Hot water storage cylinder
	DHW losses	N/A	1.6 kWh/day	N/A	1.6 kWh/day	N/A	1.6 kWh/day
	DHW tank size	N/A	200L	N/A	200L	N/A	200L
	WWHR efficiency	36%	No WWHR	36%	No WWHR	36%	No WWHR

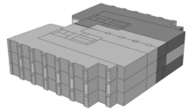
Note: For the cost modeling the specifications for the notional building was used for the baseline.

Non-residential typologies I Assumptions

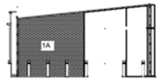
This table summarises the different energy efficiency assumptions modelled.



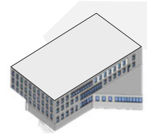
School



Office



Retail



Science & Tech

		School		Office		Retail		Science & Tech	
		Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled	Part L 2021 baseline	Specifications modelled
Fabric	Floor U-value (W/m^{2}K)	0.18	0.12	0.18	0.12	0.15	0.12	0.18	0.12
	External wall U-value (W/m^{2}K)	0.26	0.18	0.26	0.18	0.18	0.18	0.26	0.13
	Roof U-value (W/m^{2}K)	0.18	0.13	0.18	0.13	0.15	0.13	0.18	0.11
	Window U-value (W/m^{2}K)	1.6	1.2	1.6	1.4	1.4	1.4	1.6	1
	Doors (W/m^{2}K)	1.6	1.6	1.9	1.5	1.9	1.5	1.6	0.5
	Thermal bridge allowance	Part L defaults	Part L defaults	10% of losses	3% of losses	10% of losses	3% of losses	10% of losses	3% of losses
	Air permeability (m^3/m^2.h)	3	3	3	3	3	3	3	3
Systems	MVHR HR efficiency and duct insulation	Naturally ventilated	Naturally ventilated	AHU with 76% HR	AHU with 80% HR	AHU with 76% HR	AHU with 80% HR	AHU with 76% HR	AHU with 80% HR
	MVHR HR efficiency and specific fan power	1.6 W/l/s	1.6 W/l/s	1.8 W/l/s	1.6 W/l/s	1.8 W/l/s	1.6 W/l/s	1.6 W/l/s	1.6 W/l/s
	Space heating	Heat pump	Heat pump	Heat pump	Heat pump	Heat pump (VRF)	Heat pump (VRF)	Heat pump	Heat pump
		Radiators < 45˚C	Radiators < 45˚C	FCU	FCU	Radiators < 45˚C	Radiators < 45˚C	FCU	FCU
		COP - 2.5	COP - 3.5 to 4.0	COP - 2.5	COP - 3.5 to 4.0	VRF COP - 2.5	VRF COP - 3.5 to 4.0	COP - 2.5	COP - 3.5 to 4.0
	Weather compensation?	Yes	Yes			Yes	Yes	Yes	Yes
	Cooling efficiency	-	-	SEER 4.4	SEER 5	SEER 3	SEER 5	SEER 3	SEER 5
	Domestic hot water efficiency	Direct electric point-of-use hot water	Direct electric point-of-use hot water	DE to toilets A 1000L hot water store for the showers fed by a heat pump	DE to toilets A 400L hot water store for the showers fed by a heat pump	Direct electric point-of-use hot water	Direct electric point-of-use hot water	Direct electric point-of-use hot water	Direct electric point-of-use hot water
	DHW storage size	n/a	n/a	1000L	400L	n/a	n/a	n/a	n/a

Appendix C
Scenario 1 – Science and retail typologies

Scenario 1 – Science and retail typologies

Some typologies require a different approach

Energy and cost modelling has been undertaken in this evidence base in order to cover a range of different types of buildings. This modelling has been used to inform the recommendation of policy requirements. However, there are a few typologies for which this approach is less appropriate. This is particularly the case for science & tech or retail.

Energy use of science and tech buildings is very high and varies significantly across different buildings

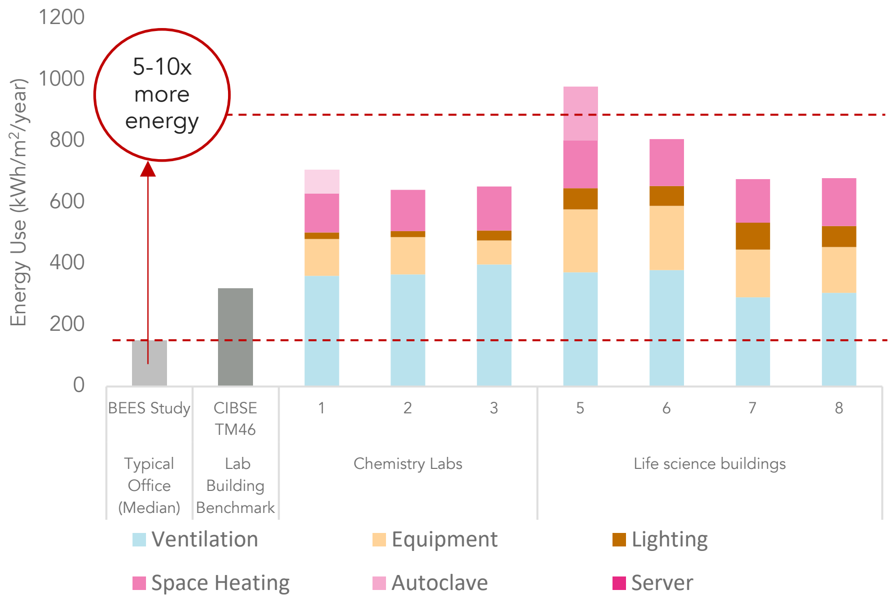
Life science buildings are generally mixed-use buildings comprising of lab and office spaces. The lab spaces could include any of the following end use types: chemistry, wet-lab or dry-lab, and each of these use types would have their specialist design teams with specialist ventilation, heating/cooling and equipment requirements. As a consequence of this variability depending on the end user, it is difficult to set a limiting energy performance for this typology.

It is very challenging predict energy use for retail spaces, particularly at planning stage

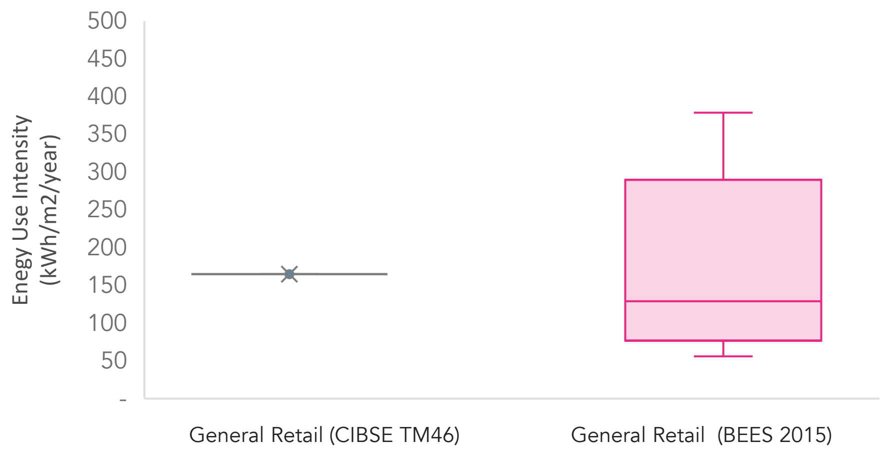
Retail units cover a wide range of end uses such as clothing, furniture, supermarkets, pharmacies, electronic store, etc. Due to the wide range of end uses with different energy consumption requirements, it is hard to predict the energy consumption of these typologies.

It is suggested that energy targets are developed for these typologies, and any others that have not been modelled in this evidence base. These should be agreed with the council as part of pre-application discussions for these typologies.

Although energy limits have not been set, a cost uplift has been developed based on an appropriate specification of building fabric and heating, hot water, ventilation and lighting systems.



Lab buildings energy consumption breakdown. Data from "Energy Consumption of University Laboratories: Detailed Results from S-Lab Audits" showing large variety in energy use.



BEES 2015 Study EUI results compared against the CIBSE TM46 benchmark for retail buildings. The BEES 2015 study presents the huge variance in EUI results emphasizing the difficulty in setting an EUI target for this typology.